SEPTEMBER 1949

Journal

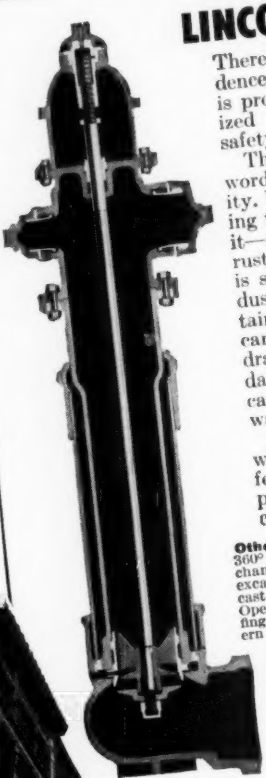
VOL. 41 • NO. 9

AMERICAN WATER WORKS ASSOCIATION

Land Waste on the Potomac Watershed

"One of America's Safest Cities"
The Mathews Firemen Say

LINCOLN, NEBRASKA



There's good reason for their confidence, because Lincoln, Nebraska is protected by Mathews Modernized Hydrants—and that means safety *plus*.

These great hydrants are the last word in simplicity and serviceability. Water cannot reach the operating thread—no risk of ice jamming it—no risk of deterioration from rust or sediment. The revolving nut is shielded against rain, snow and dust. All working parts are contained in a removable barrel which can be replaced in a jiffy if the hydrant is broken by a truck. And the damaged hydrant cannot leak, because the main valve opens *against* water pressure.

Send for our illustrated folder which tells you the many distinctive features that make Mathews indispensable for every safety-minded community.

Other Mathews Features: Head can be turned 360° • Replaceable head, nozzle outlets easily changed • Nozzle levels raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, elasticity • Operating thread only part to be lubricated • Stuffing box cast integral with nozzle section • A modern barrel makes any Mathews good as new

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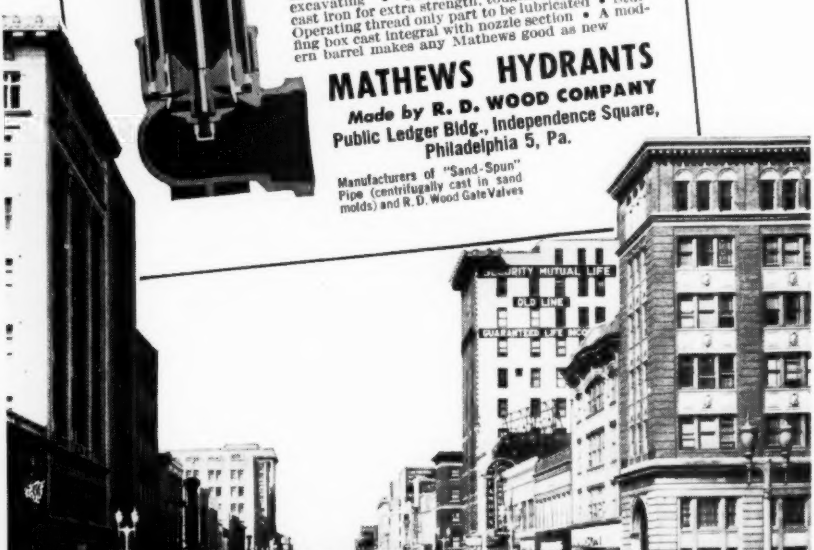
Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves



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LET IT DRIP

IT COSTS money to have a plumber repair leaking faucets and toilet bowls—so it's natural for consumers to ignore small leaks for which they pay nothing.

But when you install a system of regular meter inspection, test and repair, so that your meters will register at least 90% at 1/4 gallon per minute, the average consumer will pay a plumber to fix the leaks, rather than pay higher water bills.

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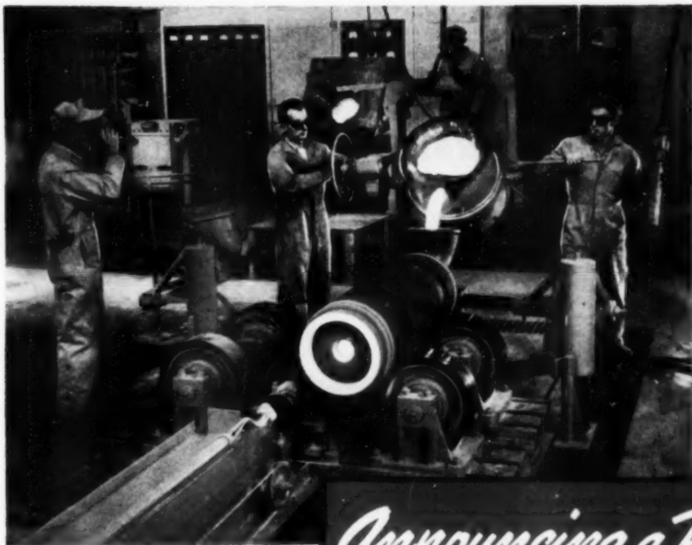

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To implement the expanded activities of our Research and Development Department in product and process research, we have built and equipped a new Research Laboratory and Foundry at Burlington where our General Offices and our Burlington plant are located. One of the largest and finest in the cast iron pressure pipe industry, its completion and recent dedication signalizes the 50th Anniversary of the founding of our Company.

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Engineering Facts about

Johns-Manville TRANSITE* PRESSURE PIPE

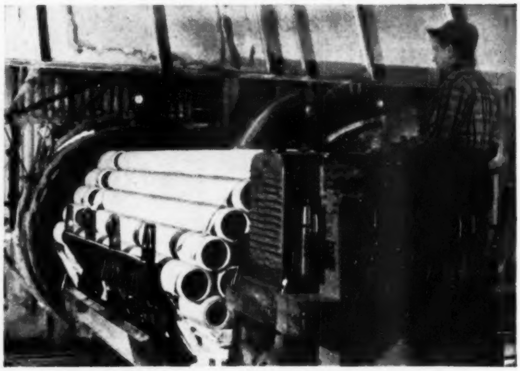
Resistance to Corrosion ...an index of long life

Ability to withstand corrosion is the most important single measure of the durability or life expectancy of an underground water pipe material. Two factors—both inherent in the pipe itself—contribute to Transite's exceptional ability to resist corrosion.

These are:

1. The inherently corrosion-resistant materials of which Transite is made.

2. The specially developed manufacturing process — employed exclusively by Johns-Manville—which imparts a high degree of chemical stability to the finished product.



A load of Transite Pipe about to enter the steam curing tanks. This step in the Johns-Manville manufacturing process contributes substantially to the corrosion resistance of the finished pipe—and, therefore, to its long service life.

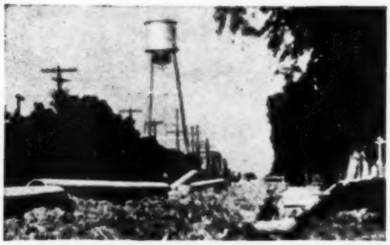
In the manufacture of Transite Pipe, the three basic ingredients, asbestos fibres, cement, and silica—all basically corrosion-resistant by nature—are consolidated under tremendous pressure to form a pipe wall of dense, uniform, homogeneous structure. After forming, the pipe is subjected to a special steam curing process.

Transite Pipe was first used by this large west coast city in 1933. Its exceptional corrosion resistance—an index of long life—has already made it possible for Transite to outlive other pipe several times over.

***Transite is a registered Johns-Manville trade mark for its asbestos-cement pipe.**

It is in this steam curing stage that so much is contributed to the stability and structural integrity of the pipe. Here under the action of pressure steam, Transite assumes a new chemical identity. The silica unites chemically with the free lime ordinarily associated with cement products and converts it into highly stable, insoluble calcium silicates. As a result, the cured pipe is unusually resistant to corrosive attack throughout its entire structure.

This intrinsic resistance to corrosion has been substantiated by numerous installa-



Transite Pipe was installed in this Texas city ten years ago to replace another pipe material that had been destroyed by soil corrosion in 7 years. The Transite mains are still on the job today with a long useful life ahead of them.

tions. Some of these have been exposed to highly aggressive soils, both alkaline and acid, for many years. Many are now serving as replacements for other types of pipe materials under conditions so destructive that their useful service life had been seriously curtailed.

Like thousands of other communities, this West Virginia city selected Transite Pipe because it promised assurance of maximum life. Today, after 14 years of service, the first installation of Transite has already fulfilled this promise by outlasting the pipe material previously used.

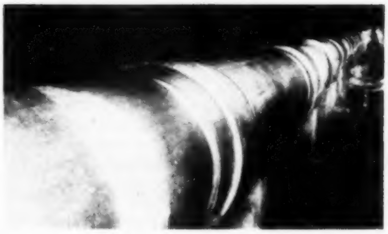
In one such installation, a Transite main installed during 1932 in an extremely corrosive soil was recently made the subject of careful study to determine its condition. Sections of the pipe, including couplings, were dug up and shipped to the factory for test. There was no evidence of deterioration. Pipe and couplings readily withstood the original factory test, equivalent to four times the normal working pressure of the line.

Certain types of industrial service provide an even more severe "proving ground" for the life expectancy of pipe materials, and here, too, Transite Pipe has demonstrated exceptional corrosion resistance. Coal mine service is a typical example. Here acid mine waters are frequently so corrosive that they have destroyed ordinary pipe materials in a matter of a few weeks or months. Yet Transite Pipe has handled these same waters under working pressure up to 150 lbs. for periods from 10 to 15 years with little, if any indication of deterioration.

To evaluate the ability of pipe materials to withstand soil corrosion, the National

Corrosive soil conditions were so severe at this location in a prominent New England city that the life of the pipe material formerly used was only 15 years. Transite Pipe, put in as a replacement in 1934, continues to give the same efficient, dependable service as the day it was installed.

Bureau of Standards has conducted an extensive series of field tests. These studies are based on examination of hundreds of pipe samples periodically removed from severely corrosive soils. In these and similar tests, Transite Pipe has consistently demonstrated its superior resistance to soil corrosion, confirming the long life expectancy which this asbestos-cement pipe has evidenced in thousands of water works installations.



Transite's ability to provide long-term, dependable service is well illustrated by its performance in coal mines, where it consistently outlasts other pipe materials in carrying corrosive mine drainage waters. The 36" Transite line shown above has been conveying acid mine waters for 15 years.

For further details about Transite Pressure Pipe, write Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

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8–9—Minnesota Section at Hotel Nicollet, Minneapolis, Minn. Secretary: R. M. Finch, 518 Metropolitan Bldg., Minneapolis 1, Minn.

14–16—Pennsylvania Section at Penn-Harris Hotel, Harrisburg, Pa. Secretary: L. S. Morgan, Dist. Engr., State Dept. of Health, Greensburg, Pa.

22–23—Rocky Mountain Section at Acacia Hotel, Colorado Springs, Colo. Secretary: O. J. Ripple, Ripple & Howe, Cons. Engrs., 426 Cooper Bldg., Denver 2, Colo.

22–23—West Virginia Section at Oglebay Park, Wheeling, W.Va. Secretary: J. B. Harrington, State Dept. of Health, Charleston 5, W.Va. For reservations write: A. R. Todd, Filtration Plant, Wheeling, W.Va.

25–27—Missouri Section at Connor Hotel, Joplin, Mo. Secretary: Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

28–30—Michigan Section at Park Place Hotel, Traverse City, Mich. Secretary: Raymond J. Faust, Div. of Water Supply, Bureau of Eng., Michigan Dept. of Health, Lansing 4, Mich.

October **6–7**—Iowa Section at Burlington Hotel, Burlington, Iowa. Secretary: H. V. Pedersen, Supt., Water Works, Municipal Bldg., Marshalltown, Iowa.

9–12—Southwest Section at Biltmore Hotel, Oklahoma City, Okla. Secretary: Leslie A. Jackson, Mgr.-Engr. Little Rock Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

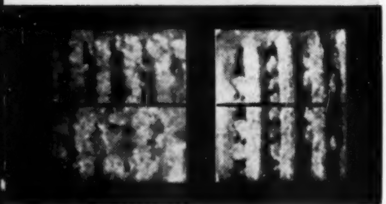
11–13—Wisconsin Section at Hotel Schroeder, Milwaukee, Wis. Secretary: L. A. Smith, Supt., Water Works, City Hall, Madison, Wis.

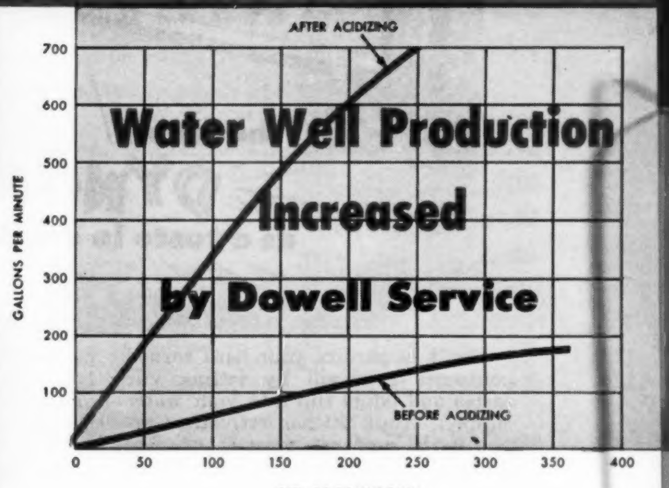
(*Continued on page 76*)

DOWELL

SPECIALISTS IN SCALE AND SLUDGE REMOVAL WITH CHEMICALS

Acidizing of the limestone core above produced the enlarged passages shown in the right hand photograph. The photographs below, taken with a subsurface camera, show the screen in a gravel-packed well before and after acidizing.





Drawdown Curves showing the advantages which have been obtained from proper chemical treating of water wells.

Scale incrustations and corrosion products on the well screen, pump, tubing and face of the producing formation will cut down the output of your water well. Dowell Acidizing Service is designed to remove these water-stealing deposits easily and quickly. Also, production may be increased due to enlargement of the water passages in the formation itself.

Case histories of many Dowell serviced wells show excellent results. For example, in a 1900 foot deep water well, calcium carbonate and iron oxide incrustations on the slotted liner had cut production to 65 g.p.m. After Dowell service, the well produced 632 g.p.m.—*an 872% increase.*

Dowell Acidizing Service requires a minimum amount of mechanical work since pulling of the pump or the screen is usually unnecessary. Experienced Dowell engineers do the entire treatment—using mobile equipment, they bring the proper solvents to the well site along with all necessary pumps, mixers and control equipment. Your nearest Dowell office will be glad to give you complete information and free cost estimates.

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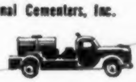

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Aqua Nuchar is specially manufactured for use in water purification. For nearly twenty years, our Research Staff has carried on tests in our laboratories and in the field to determine the correct combination of activated carbon properties to give optimum taste and odor control. Aqua Nuchar now has these special qualities: superior activation, increased porosity, greater dispersion and better suspendability. Because of its extreme fineness, it disperses more quickly throughout the entire body of water and remains in suspension a longer period of time; the exceptionally porous carbon particles have a greater opportunity to contact taste and odor bodies in the water to remove them by adsorption.

Write to our nearest office and arrange to have our Technical Service Department study your taste and odor problems.

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Journal

AMERICAN WATER WORKS ASSOCIATION

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WHAT THE RECORDER DOES: It provides a continuous, permanent record of actual chlorine residuals—either free available or total.

WHAT IT IS: The Recorder consists of a cell and a recording mechanism attractively housed in a handsome, gray enameled pedestal to complement any W&T Chlorinator installation. Optional accessories include a *Remote* Residual Indicator and a *Remote* Alarm System.

HOW THE RECORDER WORKS: In a continuous sample of the water under test, a function of the residual is measured and subsequently recorded on a 24 hour circular chart in terms of ppm of residual chlorine.

ADVANTAGES OF RESIDUAL RECORDING: Residual recording includes these big advantages—(1) Better chlorination control (2) A permanent record of performance (3) A check on operating irregularities (4) Determination of chlorine demand (5) To ascertain residuals in the distribution system (6) As a check on chlorine usage to avoid wastage, and (7) Because the record is continuous, operating data is available which could not be obtained by periodic testing.

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"—The recorder enables us to save many dollars on chlorine—"

"—This instrument functions with extreme accuracy and fidelity. It provides something that experienced water plant operators have long desired—"

"—I congratulate Wallace & Tiernan on the development of this useful equipment which is probably the most important advance in the science of chlorination in the last twenty years—"

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 41 • SEPTEMBER 1949 • NO. 9

Use of Irrigation Water for Domestic Purposes

By Robert T. Durbrow

A paper presented on April 29, 1949, at the California Section Meeting, Bakersfield, Calif., by Robert T. Durbrow, Exec. Secy., Irrigation Dists. Assn. of California, San Francisco.

IRRIGATION districts in California have been formed principally to furnish water for agricultural purposes during the long dry season, which varies from five months in the northern valleys to twelve months in the arid south. These districts have been established to extend cheap water to as great an area of farm land as it is possible to irrigate with the water available. To accomplish this objective, irrigation districts have constructed thousands of miles of canals, ditches and pipelines in all parts of the state. The majority are operated seasonally so that water runs in them during the dry season only, and the ditches are dry between crops or during the rainy season. As the canals and ditches are frequently unlined, the water in them may be turbulent and may contain silt or sediment.

It was not intended that this type of water system be used to furnish domestic water, but residents along many of the canals, having no other water source, demand this service. The increased demands for domestic service from irrigation systems have brought the districts many problems, some of which have been solved while others have not.

Health Hazard

The principal difficulty involved in the service of domestic water from an irrigation system is that such service may be, or may become, a hazard to public health. Continued immigration into all parts of California is not only accenting the hazard but is contributing to it. What were once pure and wholesome mountain streams may now be contaminated by the cesspools of the residents of the hillsides or the hamlets upstream. Irrigation canals formerly carrying clear melted snow may now be dirty drains for the closely

pastured fields on the upper slopes. The quality of the water for irrigation is not lowered by such contamination. In fact, quite the contrary is true, as elements of fertility may be carried to the crops irrigated. Beyond all doubt, however, a potential danger to public health is present as long as untreated water from such streams or canals is used for domestic purposes.

If health hazards exist and the danger is recognized, then it may logically be asked why the situation is not remedied. Actually, steps are often being taken to eliminate health hazards in most districts serving domestic water. Miles of pipe are replacing open canals and ditches every year, and settling reservoirs and treatment plants are being built where users are sufficiently concentrated to justify such installations. Then, too, if disease is ever traced to the water supply, the state laws are very strict and the department of public health is quick to see that proper precautions are taken or that the water service is discontinued. But there are still thousands of miles of open ditches in the state, and domestic services may be so far apart that the protection of the whole water supply is physically and economically impossible. Treating each water supply after it is taken from the canal is the only real safeguard.

In four districts very much concerned with this problem, a survey made a short time ago indicated that, outside the concentrated populated areas served by those districts, there were 922 miles of open ditches and canals supplying approximately 1,550 domestic services, or an average distance between consumers of more than half a mile. In the Imperial Irrigation Dist., the average distance between domestic services is considerably greater, for there are only a handful of diversions for domestic use over a canal system of 1,746 miles! Large quantities of water flow in these canals, and even when many domestic services exist, only a small portion of the total supply is used for such purposes in rural areas.

Consumer Responsibility

Who is responsible for the purity and safety of the water for these scattered domestic services? The irrigation districts have long maintained that they are in the business of furnishing irrigation water and that those using the water for any other purpose do so at their own risk. The districts resisted demands for domestic water because of the problems of pollution and contamination but also because of the seasonal nature of the irrigation supply. Scattered domestic services, once connected, can demand that water be maintained in a ditch when it normally would be dry, causing water to be wasted and maintenance and repair schedules on the ditch to be upset. Many a district, however, has found that, although it is more trouble to maintain supplies for domestic services than for irrigation, the increased charges which may be levied more than make up for the added burden. Consequently, a pipe from a ditch to a farmhouse, which at one time might have been ignored as a part of the irrigation service, is now sought out and charged the higher domestic rate.

A graphic illustration of an attempt to meet these difficulties is contained in the following application for water for domestic use from the El Dorado Irrigation Dist. near Placerville.

Application for Water for Domestic Use

To El Dorado Irrigation District:

Being unable to obtain water for domestic use from any other source, other than from the works of El Dorado Irrigation District, and realizing that El Dorado Irrigation District is primarily engaged in furnishing water for irrigation purposes, I hereby make application for water to be used for domestic purposes to be furnished from your ——— canal or ditch, subject to your rules and regulations, to begin ———.

I fully understand that your rate is $—— per month without a meter, or $—— per month when furnished through a meter, said minimum payment when furnished through a meter entitling the user to the use of 750 cu.ft. per month, any excess to be paid for at the established meter rates. Said rates being subject to change by the Board of Directors.

It is also understood and agreed that El Dorado Irrigation District furnishes water for domestic use only when another supply is not available, and that the said District does not warrant that said water, so furnished, is fit for domestic use, is healthful or potable, and that in purchasing and using said water for domestic use the undersigned does so solely at his or her own risk.

It is also understood that said water shall be available only when El Dorado Irrigation District has a supply in its system sufficient to furnish the same. It is also recognized that El Dorado Irrigation District is not required to maintain a continuous supply of water in said ditch or system. It is further recognized and agreed that the District shall have a right to discontinue furnishing water for domestic use at such times as a substitute supply may be available for my use, or at such times of the year as the District finds it impracticable to continue water in said ditch, or finds that said water cannot be furnished me without loss to the District.

It is further understood that water furnished under this application shall not be used for irrigation purposes.

Attorneys disagree on whether or not the applicant's signature on such a form absolves the district of all responsibility for the purity and safety of the water furnished, but whether it does or not, certainly it puts the water user on notice that reasonable precautions should be taken if the water is to be used for human consumption.

A similar precaution is taken by the Nevada Irrigation Dist. in the furnishing of domestic water. Printed on the face of each application for water is the statement: "Water furnished by Nevada Irrigation District under this application is not treated to make it safe for drinking purposes and anyone using same for such purposes does so at his own risk." The same statement is printed on the back of the application as one of the "Conditions of Acceptance of Water Service" and is recorded as "Rule 1" of the "Rules for the Distribution and Use of Water and Charges for Service."

Although both of the above districts disclaim responsibility for the safety of the domestic water furnished, they are each engaged in programs of improvement of the water supply to the extent of their financial ability to do so. The plans of the districts include the extensive replacement of open ditches with pipelines, the lining of canals with concrete and major improvements in reservoir space, dam repairs and protection of the supplies.

Effect of Population Increase

Irrigation districts have felt the pressure of increased population just as has almost every other area or city or town in the state. Many districts

formed in rural areas have been built up so that they are now suburban, and some could even be called urban. The effect of this influx is illustrated by the decreasing size of farms in three irrigation districts covering 10,000 acres east and north of Sacramento. Fifteen years ago the average property holding in this area was 30 acres, and today the average holding is 2½ acres. In about the same period of time in the Fresno Irrigation Dist., which, with 236,000 acres, is one of the largest in the state, the average holding has decreased from 52 to 14 acres. As this trend toward smaller farms is general, the districts have been kept busy and financially hard-pressed to furnish the expanded service necessary and to keep up with the additional administrative burdens resulting from the greatly increased number of parcels of land. Many of the purchasers of small farms are retired or elderly persons who receive pensions or other income and wish to supplement it by farming or working out.

It is frequently this type of person who is receiving domestic service from an open ditch in an isolated location. The furnishing of individual water treatment equipment for each of these scattered residents has been suggested, but no practical, dependable equipment is available within the financial means of these people. They would resist strenuously any attempt to force them to accept and pay for expensive treating equipment, and, as has been pointed out by officials of the state department of public health, it would be an impossible task to try to take action against every individual in the state who did not want to install and pay for an individual water treatment device.

Even if it were possible to require every individual to treat his supply, or if the district were required to do it for him, the results might leave much to be desired. A recent statement by the University of California Extension specialist in agricultural engineering bears on this subject. Asked about the availability of chlorinating units for small water services, he replied: "I am not acquainted with the automatic chlorinating device which you mention in your letter for $100. In fact, I have not yet seen an automatic chlorination unit that really worked." In view of such a statement, it is obvious how difficult it would be to require a district or an individual to make a large investment in such equipment.

Pure Water Law

As it is felt that those taking water service from irrigation systems are themselves responsible if the water is used for drinking, and as enforcement of the sanitation laws against each individual is impractical and almost impossible, the California Pure Water Law makes certain exceptions for the individual who supplies his own water and also for the purveyor of domestic water who supplies less than 200 service connections. The Pure Water Law (which defines a "person" as any public utility, municipality or other public body or institution, and "board" as the state board of public health) states:

4011. No person shall furnish or supply water for domestic purposes from any source of water supply, unless he first files a petition for permission to do so with the board and receives a permit as provided in this chapter.

4024. No permit is required of any person supplying water for domestic purposes on his own private property upon which there is no industrial camp, hotel, or temporary or permanent resort using

the water, or supplying less than 200 service connections, unless a formal complaint is filed with the board.

Section 4024 when first adopted eliminated most irrigation districts from the permit requirements and was intended to do so because of the problems which have been discussed. Some of the districts, however—as, for instance, the four previously mentioned in which there were 1,550 domestic services from 922 miles of canals—have service connections far exceeding the 200 for which exemption from the permit requirement is granted. Because these services are from open ditches and there is *always* the possibility of pollution along the system, the health department would not and could not issue such districts a permit for the service of domestic water. As a result, the districts are constant violators of the law, if the individual domestic water services are deemed to be service connections.

Proposed Legislation

To remedy the situation, two pieces of legislation have been presented to the 1949 California legislature.

The first of these bills exempts irrigation districts from the permit requirements of the California Pure Water Law except in specific areas concerning which the department of public health gives written notice to the district. This provision gives the department of public health authority over the districts in the event of an actual health hazard, but it eliminates the vice of the present law which automatically makes the directors of a district guilty of a crime for serving water without a permit. This legislation would reverse the situation, so that, instead of first requiring the districts to obtain a permit (which they cannot obtain), the department of public health is required to determine in advance that the district must have a permit for the serving of domestic water in a particular area.

The second bill adds to the California Pure Water Law definitions of the words "user" and "furnish or supply," as employed in that law. Briefly, a "user" is defined as a user of water for domestic purposes, excluding any person or agency supplying water to the public. Thus, a farmer taking domestic water would be a user, but a city or town taking a domestic supply would not be a user. "Furnish or supply" is defined as supplying water to two or more places of human habitation connected by a pipe system, but is specifically defined as not including supplying water to a user in a rural area for domestic purposes if the user receives the water directly from an open irrigation canal system.

The effect of this bill would be similar to that of the first proposal, with the difference that the second would exempt services from canals in rural areas whether or not they were in an irrigation district. The first proposal would apply only to irrigation districts, but would apply to the whole district, whereas the second proposal would be more restrictive in that it would exempt only those portions of the district in which domestic services are made from open ditches.

The two proposals are not incompatible, and if they are both adopted they should make the enforcement of the California Pure Water Law much more practical and feasible than it has been in the past. The state director of

public health, Wilton L. Halverson, has endorsed the proposed definitions of "user" and "furnish or supply," stating that he believes they will clarify the meaning of the code sections and be helpful to the department of public health in its administrative work.

[NOTE: Since this paper was written, the two proposed bills discussed have been passed by the California legislature and signed by the governor. A third bill to become law eliminates the exemption from the Pure Water Law for suppliers of less than 200 service connections (in Sec. 4024 as cited).—*Ed.*]

Summary

The problems which have been discussed in this paper are principally those affecting districts where underground or other alternate supplies of water are scarce or not available at all, and where large quantities of water are carried in open canals for irrigation purposes. Other important factors in these problems are the scattered nature of the domestic water users and the difficulties encountered in attempting to safeguard the individual supply.

One solution to such problems is the further protection of the water supplies so that the health hazard is minimized, and the increased piping and treatment of supplies when feasible, so that absolute protection is afforded. The other solution takes the form of placing the responsibility on the user if domestic water is taken from open canals in rural areas. Both solutions are in line with common practice in rural areas. There are exceptions to the common practice, as in all things, and there are instances in which specific remedies must be found, but the law is believed to be strong enough to cope with the serious situations. In the others, it may be necessary to encourage progress by education, illustration, demonstration and the exercise of patience in generous measure.

This Month's Cover

Too experienced to be taken in by the outward tranquility of the rustic scene on the cover, most readers will recognize the menace of the mud and gravel deposits clearly visible in the foreground. The locale of the photograph (reproduced through the courtesy of the District of Columbia) is the Potomac River watershed, where 30,000,000 cu.ft. of soil is washed away every year. Aside from the loss to agriculture, the resultant high water treatment costs, flood damage, harbor siltation and destruction of aquatic life constitute a most disturbing problem. For an excellent review of such soil pollution and its effects, see the article by Harold A. Kemp in this issue (p. 792).

Effect of River System Development on Water Quality in the Tennessee Valley

By F. W. Kittrell and Fred W. Thomas

A paper presented on June 3, 1949, at the Annual Conference, Chicago, by F. W. Kittrell, Chief, Stream Sanitation Sec., and Fred W. Thomas, Public Health Engr., Tennessee Valley Authority, Knoxville, Tenn.

FIRST priority for water resources development [should] be afforded to beneficial consumptive use, present or future, of waters for domestic and municipal purposes."

This quotation is from a statement defining the official policy of the A.W.W.A. on national water resources (1). Federal adoption of the Association's policy should assure adequate protection of public water supply interests in national resource development programs.

No comparable priority was assigned to the consumptive use of water by Congress in establishing the Tennessee Valley Authority and directing it to develop the natural resources, including water, of one of the major river basins of the nation. A review of actual experience in the Tennessee Valley during the sixteen years since the authority was established reveals how public water supplies have fared in the development of an area where no such priority was assigned.

Tennessee Valley

The area of the Tennessee River drainage basin (Fig. 1) is 41,000 square miles. It includes portions of seven states and in 1940 had a population of approximately 2,500,000.

The French Broad and Holston Rivers flow from North Carolina and Virginia to form the Tennessee River at Knoxville, Tenn. The river flows toward the south to pass through northern Alabama and back toward the north through western Tennessee to join the Ohio River at Paducah, Ky., 650 river miles below Knoxville. The mean annual rainfall of 51.7 in. sustains a mean annual discharge of 65,000 cfs. into the Ohio.

The geology of the valley is such that large quantities of good-quality underground water generally are available in only the predominantly agricultural western one-third of the basin. The more thickly populated and more highly industrialized eastern area depends on surface streams for comparaable sources of water. Tributary streams with extremely soft water from North Carolina mix with moderately hard-water tributaries in Tennessee to produce water in the main river at Chattanooga and downstream with a hardness of about 65 ppm. In 1940 Tennessee Valley municipalities with a combined population of 880,000 were served by 261 public water supply systems.

TVA has harnessed the river system for navigation, flood control and

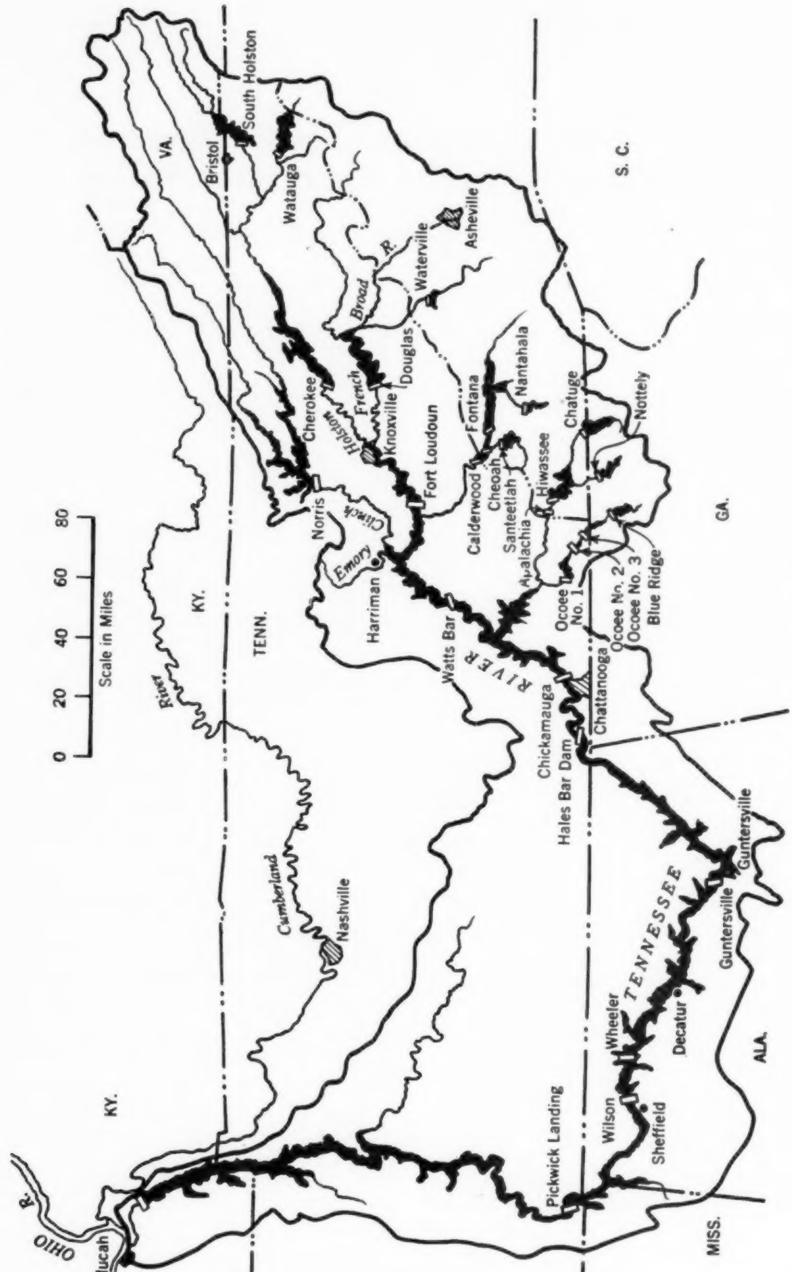

FIG. 1. Tennessee Valley

power production through the construction of ten dams on tributary streams and seven on the main river, and the acquisition of or negotiated agreement for the integrated operation of fourteen tributary and two main river dams built by others. Another tributary dam is under construction.

These dams form reservoirs with a combined storage capacity of 21,700,000 acre-ft. The useful controlled storage capacity of 14,200,000 acre-ft. could maintain a river with a discharge of 19,500 cfs. for a year. The total reservoir shoreline is 10,000 miles, and the combined surface area of 1,130 square miles is 2.75 per cent of the drainage basin area.

Governing Principles

The fifth amendment to the U.S. Constitution prohibits the taking of private property without due compensation. The provisions covering TVA rights of eminent domain and of conveyance supplement this constitutional amendment to assure full compensation for water works properties that are flooded or destroyed, provided they are not situated in a navigable stream channel. The federal government recognizes no liability for damage to properties in navigable stream channels, on the basis of its right to develop navigable waters for navigation and flood control, which is paramount to the rights of all other parties. Previous or existing use of either the channel or the water by other parties does not establish an inherent right, but is exercised through the sufferance of the federal government. Under this principle, the government can, without liability, stop completely the flow of water in a navigable stream channel below a dam built for navigation or flood control, even though a downstream municipality is dependent on the stream for a source of water supply. The government can require removal, without compensation, of any structure in a navigable stream channel that interferes with navigation or flood control activities.

The government is not liable for consequential damage unless it accompanies the taking of property. Even in a nonnavigable stream, it is not liable for the deterioration of water quality that follows as a consequence of impoundage, for example, unless the property of the water works affected is taken in the process. If, on the other hand, a spring owned by a municipality and used as a source of water supply is flooded, ordinarily not only must the source be replaced but the quality of the new source must be at least equivalent to that of the original.

The act creating TVA and defining its responsibilities, together with subsequent amendments, gives priority in control of the river system to navigation and flood control. The control of water for power production is designated as secondary to these prime purposes. At this point, specific directives for the control of water end.

TVA is authorized to negotiate contracts for the relocation of railroads, highways, bridges, electric-light plants and even mills and ferries, where the removal of such facilities is necessary to carry out the provisions of the TVA Act. Water works are covered by the catchall phrase "and all other properties." The authority is authorized to convey lands, easements and rights-of-way to water companies, among specified agencies, to replace similar properties and rights flooded or destroyed

by the construction of dams or reservoirs. A fundamental purpose of the act is to foster "an orderly and proper physical, economic and social development" of the Tennessee Valley. A program designed to accomplish this purpose inevitably recognizes the essential nature of public water supplies.

Effect on Structures and Properties

Forty-one water supplies, serving a population of nearly 400,000, have been affected in some degree by the river system control program (Table 1).

Effects on physical items, ranging from the flooding of a simple intake structure to the complete inundation of a town with a water system, are concrete matters, subject to reasonably precise evaluation. Previous articles (2, 3) have reported most instances of this kind in the valley. Only a few justify brief repetition here as illustrations of various types of adjustments made.

Structures have been affected in sixteen systems serving 170,800 persons. Engineering estimates of reimbursements or replacements totaled $885,000. A few towns selected cash settlements as the method of adjustment and assumed responsibility for making their own replacements, but most elected replacement in kind by TVA. Staff engineers of the authority prepared plans and specifications for the replacements and obtained the approval of the state health department having jurisdiction. The facilities were installed by TVA construction forces and received final health department approval before transfer to the towns. It is noteworthy that an appeal to the courts was not necessary to achieve a single settlement.

Professional integrity and common sense played an important role in replacement activities. Regardless of the deficiencies in existing facilities being replaced, the new installations met the requirements of sound design and construction engineering practice.

TABLE 1

Populations With Public Water Systems Affected By Impoundage

	No. of Systems	Population	
		No.	*per cent*
Total in valley		2,553,000	100
With public water systems	261	880,000	34.5
Served by surface sources	87	620,300	24.3
Affected by impoundage	40	398,400	15.6
Water characteristics affected	37	389,100	15.2
Physical properties affected	16	170,800	6.7
New sources required	5	10,200	0.4

Bristol, Tenn.

The Bristol water works intake is about 1 mile below a storage dam now under construction on the nonnavigable South Fork Holston River. If all the turbines were idle following completion of the dam, the only flow below it would be a very small amount of local inflow and leakage through the

dam unless special provisions were made for the release of water. This situation is the only one of its kind in the valley involving a water supply. A weir will be built across the river below the intake and a special supply line will be installed through the foot of the dam. This line will deliver 20 mgd., which is four times the rated capacity of the water treatment plant and nearly seven times the present consumption.

Special temporary arrangements are planned to assure a source of water for the town during the two- to ten-day period between the closure of the dam and the rise of the impounded water to the level of the special supply line intake.

Jefferson City, Tenn.

The chlorinated spring source of water for Jefferson City, a town of 2,600 population, was flooded. The hardness of the spring water was about 200 ppm. A much greater flow was available from another spring with water of comparable hardness but poorer sanitary quality due to higher coliform organism, turbidity and color content. To assure water quality from the new source equivalent to that of the existing source required the installation of a filtration plant. Upflow sedimentation, which gives good performance in softening plants, achieved economy of design and yields potable water with a hardness of only 85 ppm.

A cash settlement of $25,000 was made to compensate for the increased cost of operating the more complex treatment facilities.

Kingston, Tenn.

The Tennessee Dept. of Public Health requires a rating of 90 points before approving a municipal water supply. The rating of the Kingston supply, serving 880 persons, was 75 points. Inadequate protection of the spring source, which was subject to occasional flooding, and deficiencies in high-service pumping equipment contributed to the low rating. The spring and pumping station were in the backwater area of a proposed reservoir.

It appeared that a sufficient quantity of water for a new source might be obtained by drilling a well to an underground fault, but geological evidence indicated that the well probably would be polluted through underground connections to the nearby river. A spring several miles from town was properly protected and the water delivered to the distribution system by a new high-service pump in a new pumphouse, with the old pump as a standby.

These improvements, combined with others made by the town, contributed to an increase in rating which subsequently justified approval of the supply by the Dept. of Public Health.

Lenoir City, Tenn.

Two raw-water intake lines on the bottom of a navigable river channel served Lenoir City's water plant. One drew moderately hard water from the main river, and the other extended across the river to the mouth of a soft-water tributary stream. Both lines would have interfered with navigation and dredging operations necessary to maintain the 9-ft. navigation channel. The town was required to remove the intake lines at its own expense. The new intake line, paralleling the bank of the main river, cannot draw soft water from the tributary stream. No records are available to reveal the

change in hardness that accompanied the revision in intake lines.

Rockwood, Tenn.

Water which flowed by gravity through vitrified terra-cotta lines from springs to a pumping station near the river served as the source of supply for Rockwood. Chlorination was the only treatment employed. The old pumping station, which was to be flooded, was replaced by a new one. The gravity line from one of the springs was to be replaced, using cast iron with leaded joints. The new line was to run near the edge of the reservoir, and the state health department suggested that it should be placed above the normal reservoir level. This was done, although it required more expensive construction, including two ravine crossings, with the sections of line encased in concrete.

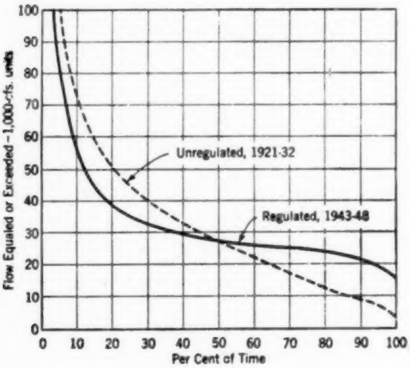

FIG. 2. Flow Duration Curves (Chattanooga, Tenn.)

Effect on Stream Discharge

Duration curves of average weekly stream flows for the Tennessee River at Chattanooga before and after impoundage (Fig. 2) reveal a marked reduction in the range of discharge fluctuations that is typical of the controlled main stream in the valley. The same data (Fig. 3), plotted as average discharges for the individual months, reveal the redistribution of discharges throughout the year, with a shift of the minimum-flow period from September and October to June and July.

No water supply has experienced any problem known to be due to inadequate stream flow resulting from control of the river system. The range of fluctuations in water levels on the main river reservoirs has been reduced and simplifies the design and operation of raw-water pumps.

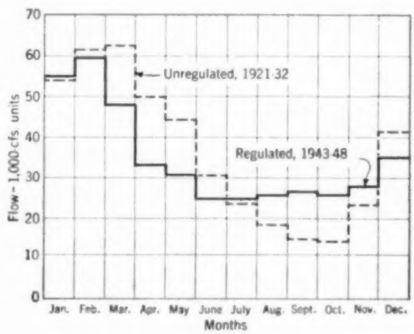

FIG. 3. Monthly Mean Flow (Tennessee R.—Chattanooga)

Effect on Water Quality

Impoundage is assumed to have affected the water quality of any supply now drawn from a reservoir or from a stream below any major reservoir. The effects may vary from slight reductions in the fluctuation of water characteristics, which are difficult to evaluate, to major changes in quality of which even the water consumers are aware. Including supplies for which new sources were necessary, the water

quality of 37 systems, serving municipalities with a population of 389,100, has been affected (Table 1).

A review of available water plant operation records to obtain a basis for evaluating changes in water quality generally yielded disappointing results. Few of the 37 towns involved had reasonably adequate records for both pre- and post-impoundage periods. Not one had complete records for both periods on the coliform organism content of the raw water, which is the single most important measure of raw-water sanitary quality. The records gradually have improved over the years, and a few towns which had in-

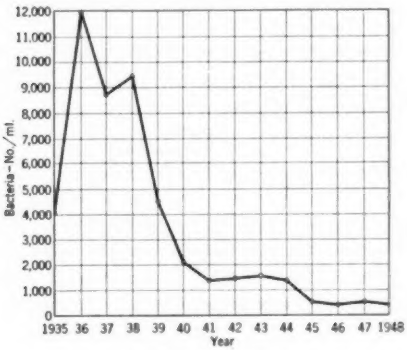

FIG. 4. Raw Water Bacteria Count (Chattanooga, Tenn.)

adequate pre-impoundage records now have acceptable operating data, but the desired comparisons, unfortunately, cannot be obtained from these.

Few records previously had been analyzed to determine changes in water quality following impoundage. In a number of instances, changes that coincided with or closely followed impoundage had been attributed to its effects, but a critical examination of the available data revealed that they were due to other causes. The adoption of improved methods of water treatment and revisions in equipment often made it difficult to separate the effects of these changes from those resulting from impoundage.

Most of the reservoirs developed by TVA were impounded during the period 1936–44. The periods covered by water plant operation records used for comparison of pre- and post-impoundage data varied from town to town, depending on local factors. In general they included four to five years in each period.

Bacteria

Coliform organisms, as an index of sewage pollution and potential pres-

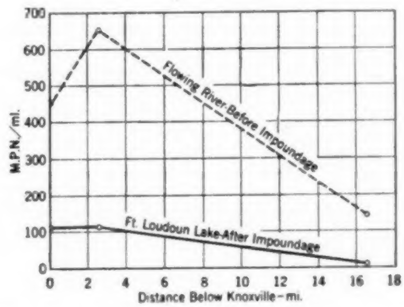

FIG. 5. Coliform Organisms Before and After Impoundage (Ft. Loudoun Lake)

ence of pathogens, constitute the most significant criterion of sanitary quality for water supplies. Kittrell and Quinn (4) have shown an 80 per cent decrease—from 1,050 before, to 210 per 100 ml. following, impoundage—at the 50 per cent time ordinate of pre- and post-impoundage coliform duration curves for Knoxville raw water. Bacterial plate counts on Chattanooga raw water decreased 97.5 per cent, from 12,000 per milliliter in 1936 to 300 in 1948 (Fig. 4). An exception to the

usual trend toward bacterial reductions following impoundage, which occurred at Harriman, Tenn., is described in the section on temperature.

Although not involved directly with an existing source of water supply, a striking example of the decreases in coliform organisms that result from the conversion of free-flowing streams to reservoirs is afforded by a comparison of the coliform content of the Tennessee River below Knoxville before (5) and after (6) impoundage of Fort Loudoun Reservoir (Fig. 5).

Temperature

Radical changes in temperature (Fig. 6) have occurred in streams immediately below storage reservoirs (7). Summer stratification usually starts in the typical reservoir in April, with the reservoir one-third to one-half full of water that entered during the winter with a temperature of 40°–45°F. The turbines, with intakes deep in the reservoir, discharge the cold water until either all of it is withdrawn or the fall turnover occurs in November. The temperature of the turbine discharge gradually increases as summer advances, but rarely reaches the pre-impoundage peak summer temperature of 85°–90°F. Following the fall turnover, the reservoir remains isothermal through the winter, since temperatures are not low enough to cause winter stratification. The mass of water in the reservoir cools to winter temperature more slowly than that in free-flowing streams, and the water discharged through the turbines is warmer than that in surface streams during November and December. The temperature then approximates that of the surface streams until summer stratification starts.

The water drawn from the cold bottom stratum usually has low dissolved oxygen, high carbon dioxide—which reduces pH—and occasionally some hydrogen sulfide. No known difficulty has been caused in downstream water supplies by any of these changes. The withdrawal of water from the bottom rather than the surface stratum, where algae develop, probably accounts for the absence of algal tastes and odors in water supplies below storage reservoirs.

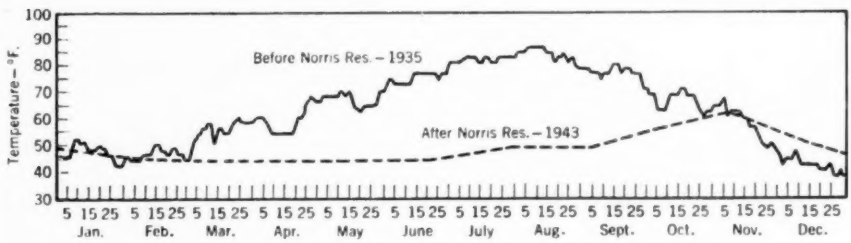

FIG. 6. Clinch River Temperatures

The temperature of the water in streams below storage reservoirs increases or decreases toward that of the atmosphere as the water flows downstream. At Knoxville, 35 and 55 miles, respectively, below reservoirs on two tributary streams, the mean annual temperature decreased 4.1°F. following impoundage (4). At Chattanooga, on the main river below all storage reservoirs, the decrease was 3.0°F.

When the cold water comes in contact with warmer water downstream, it produces density currents, with sometimes unanticipated results. The Harriman situation, which has been reported by Churchill (8), is the outstanding and only serious example in the valley.

Cold water in the Clinch River released from Norris Reservoir, 76 miles above the confluence of the Clinch and Emory Rivers, flows upstream on the bottom of Emory River for a distance of 14 miles in summer. The warmer Emory River water flows downstream on the surface. When the release of cold water from Norris is reduced, the cold Clinch water flows downstream on the bottom and the warm surface water flows upstream to replace it. Raw sewage and industrial wastes—including those from a pulp and paper mill—discharged at Harriman are carried upstream to the water works intake by the reversals of flow, with the effect on water quality shown in Table 2. This table is a summary of operating records for a month when conditions were the worst ever encountered (9). The average chlorine dosage was approximately that used to chlorinate raw sewage. The cost of chemicals for treatment was nearly $50 per million gallons, which is comparable to costs for the chemical treatment of industrial wastes. When pollution from the town and water from the Clinch River are not present at the intake, the Emory River source provides water with relatively low coliform content and color, moderate turbidity and chemical requirements, and hardness and alkalinity of approximately 10 ppm.

The operator of this small plant, serving a population of 5,600, deserves unlimited credit for the alertness, ingenuity and common sense with which he met an almost insoluble problem. He was not always able to prevent some taste and odor in the treated water, but on only one or two occasions were coliform organisms found in the finished water, at which time he promptly issued boiling notices.

TABLE 2

Post-Impoundage Records (Harriman, Tenn., Oct. 1947)

Characteristics	Av.	Max.	Min.
Raw Water			
Color—*ppm.*	107	200	30
Turbidity—*ppm.*	42	80	5
pH	7.5	8.6	6.8
Carbon dioxide—*ppm.*	7	22	0
Alkalinity—*ppm.*	105	154	27
Hardness—*ppm.*		138	34
Coliform index—*No. per ml.*	59	1,000+	10
Bacteria—*No. per ml.*		180,000	20
Finished Water			
Chlorine residual—*ppm.*	0.7	2.0	0
Color—*ppm.*	12	35	0
pH	8.1	9.0	7.1
Carbon dioxide—*ppm.*	3	18	0
Alkalinity—*ppm.*	75	115	31
Hardness—*ppm.*		194	74
Coliform index—*No. per ml.*	0	0	0
Chemical Dosages—*ppm.*			
Alum	171	291	38
Lime	123	176	46
Chlorine	22	41	4.4

The town, the pulp and paper mill, the Tennessee Dept. of Public Health and the TVA cooperated in determining the cause of the stream flow reversals and in devising methods to overcome the difficulty at the water plant. Heroic measures were employed. The pulp and paper mill op-

erated barges to transport its most concentrated wastes for discharge into the Tennessee River below the mouth of the Clinch, and to return and tie up at the water works intake with clean water taken from the Clinch above the mouth of the Emory. In cooperation with TVA the mill developed and, at its own expense, installed facilities for the temporary treatment of its less concentrated wastes. Subsequently it has made process changes that have reduced still further the mill stream near the upper end of the backwater, where pollution due to upflow is at a minimum.

The situation is unique also from the standpoint of the responsibilities involved. The Emory River had been designated as navigable up to the points where the mill wastes and much of the city sewage are discharged, but not as far upstream as the water works intake. The TVA Div. of Law has expressed the opinion that: the federal government is not liable for

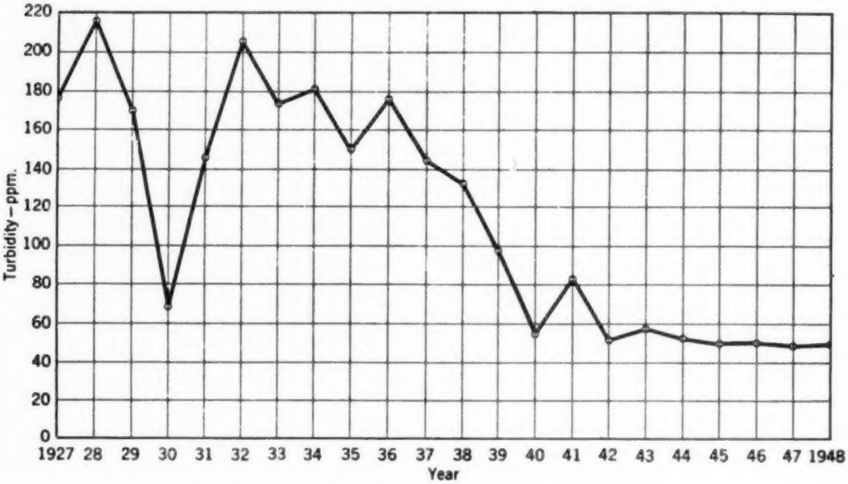

FIG. 7. Average Annual Turbidity (Chattanooga, Tenn.)

wastes discharged to the Emory. The state health department and TVA provided personnel and facilities for the necessary technical studies. When the cause of the current reversals was established, the TVA, with a loss in operational flexibility and efficiency, operated the Norris turbines at a constant rate during an entire summer to maintain a constant direction of flow in the Emory. Ultimately, the town, at its own expense, installed a new water works intake about 2 miles upstream near the upper end of the backwater ... changes in either quality or quantity of water in a navigable stream following development of the stream by the government; the discharge of wastes to a navigable stream does not result in an acquired right by those responsible for the discharge; the government is not responsible for the pollution resulting from such waste discharge; and the TVA could not build structures to correct the situation without violating established policies.

Turbidity

Turbidity has been reduced strikingly by all of the larger reservoirs. This result is beneficial in the higher ranges of turbidity, since it makes for an overall saving in alum requirements, but it is not an unmixed blessing. Difficulty is encountered in coagulating cold water with extremely low turbidity at some water plants, and a supplementary chemical, usually ferric chloride or sulfate, is sometimes necessary. Data from Chattanooga records are typical, with a 78 per cent reduction in average annual turbidity, from 180 to 40 ppm. (Fig. 7). At Knoxville, the reduction in turbidity was 61 per cent.

The reductions in turbidity accomplished by the reservoirs raise the question of the effect of siltation on reservoir capacities. This is not a problem of immediate concern in the Tennessee Valley. Careful siltation studies conducted before and following impoundage indicate that between 1,000 and 4,000 years will be required to fill the major reservoirs with silt.

Color

With the exception of a few stream sections below pulp and paper mills, the color of streams in the Tennessee Valley is of only minor importance. Routine determinations are made at Knoxville, Chattanooga and Harriman alone. The average annual color at Knoxville decreased 36 per cent, from 22 to 14 ppm., following impoundage. A 65 per cent reduction in wastes from a large upstream pulp and paper mill, as well as impoundage, probably contributed to the reduction. Significantly, the greatest reduction occurred in the higher ranges of color, to facilitate the production of a finished water with consistently low color.

Color at Chattanooga has remained at about the same low annual average of 8 ppm. Moderate increases occurred during 1935–37 and 1940–42 but cannot be attributed to a definite cause. Color bodies from vegetation on the bottoms of newly impounded reservoirs may have played a part. Unusually low mean annual discharges during 1940–42 may have contributed to the increase during that period. Of greater interest is the change in reaction of color following impoundage reported by the Chattanooga operator. The application of lime ahead of the sedimentation basins, previously practiced, appeared to fix the color. A shift in the point of application to the settled water ahead of the filters corrected this difficulty. A new structure to house the lime machine was necessary.

Manganese

Contrary to frequent experience with impounded waters, no positive evidence of difficulty with manganese is attributable to the development of TVA reservoirs. Both Knoxville and Chattanooga operators reported evidence of manganese following impoundage, but in both places it is probable that coincidental occurrences merely called attention to conditions that previously had existed undetected. At Knoxville, manganese stains appeared on the chlorinating apparatus and the filter sand following the adoption of free residual chlorination. At Chattanooga, a change in method by a large industrial consumer developed a need for process water of extremely low manganese content, which was met by prechlorination and lime treatment that reduced manganese from 0.09 to 0.02 ppm.

Alkalinity

The average annual alkalinity has not changed significantly because of impoundage. A 6 per cent increase occurred at Knoxville, contrasted with a 5 per cent decrease at Chattanooga.

Hardness

Changes in average annual hardness have been minor. A 9 per cent increase at Knoxville probably was due chiefly to industrial wastes. A 9 per cent decrease at Chattanooga may have resulted from control of the river system. High stream discharges with low hardness which formerly passed Chattanooga in a relatively few days are controlled and spread over longer periods. Conversely, low stream discharges with high hardness which formerly persisted for several months each year now are routed past Chattanooga in shorter periods to maintain higher minimum flows. If the increase in hardness due to industrial wastes above Knoxville had not occurred, it is probable that an even greater reduction would have resulted at Chattanooga.

pH

Changes in pH were insignificant. A reduction of 0.1 in annual averages followed impoundage at Chattanooga and Knoxville.

Tastes and Odors

There are no reports of objectionable tastes and odors in water supplies taken from the Tennessee River system prior to 1939. In that year, with only one storage and three main river reservoirs completed, moderate tastes and odors occurred in the Wilson Dam and Sheffield, Ala., supplies; and a severe problem developed at Paducah, Ky. At the peak of the difficulty, 138 ppm. of activated carbon reduced the threshold odor from 100 to 12 but failed to achieve complete control. The source of the difficulty was not established definitely, since the Paducah intake draws a mixture of water from the Ohio and Tennessee Rivers. Moderate tastes and odors have recurred in the raw water every summer since 1939 but have been amenable to control with reasonable dosages of activated carbon.

Each summer or fall of 1942–47, tastes and odors of varying intensity have occurred in the Sheffield, Wilson Dam, Decatur and Guntersville, Ala., water supplies on the Tennessee River. The taste, variously described as musty, earthy or grassy, is thought to result from the decomposition of algae developed in the favorable environment of extensive shallow, clear embayments. Surprisingly low threshold odor values of 10 to 12 in the raw water and 2 to 3 in the finished water have caused widespread consumer complaints, and none of the usual methods for taste and odor control has proved successful.

Representatives of the municipalities, the Alabama State Dept. of Health, commercial water plant equipment and chemical companies, and TVA have cooperated in seeking to identify the source of the difficulty and to devise an effective method of control either at the source or in the water plants. The attack on the problem is continuing with the added cooperation of the U.S. Public Health Service.

Fluctuations in Characteristics

All water plant operators from whom opinions regarding the effect of impoundage have been obtained—with the

understandable exception of the Harriman operator and those concerned with taste and odor control—were convinced that plant operation has been simplified by reductions in the rate, frequency and range of fluctuations in water characteristics due to impoundage. The frequency and range of chemical feeding machine adjustments required have been reduced because of more nearly constant turbidity, color, pH, alkalinity and chlorine demand.

Duration curves of daily values for these and other constituents, including coliform organisms, have shown increased constancy of characteristics even for Knoxville raw water, where the intake is immediately below the confluence of two tributary streams with widely different water characteristics, subject to upstream control (10). The consistent production of potable drinking water generally has been facilitated.

Chemical Requirements and Costs

So many factors obscure the true effect of impoundage on chemical requirements and costs that accurate comparisons are difficult. Although the chlorine demand of stored water generally is reduced, the adoption of new and improved chlorination practices has resulted in increased use of chlorine. During the period covered by this article, chloramine residuals have been increased and prechlorination and free residual chlorination have been introduced at a number of plants.

No increase in the aggressiveness of water due to impoundage has been found, but better understanding and acceptance of corrosion control practices have resulted in increased use of lime.

Alum requirements at Knoxville, Chattanooga and South Pittsburg, Tenn., have been reduced 11, 18 and 28 per cent, respectively. The lower alum dosage at Chattanooga is partially counterbalanced by the supplementary use of ferric chloride and copper sulfate since impoundage. On the basis of current costs of the chemicals used, it is estimated that the cost of coagulants has been reduced about 17 per cent. After making adjustments for increased unit costs of chemicals and increased use of chlorine due to the adoption of free residual chlorination at Knoxville, it is estimated that an 18 per cent reduction, amounting to about a $6,000 average annual saving, in the cost of chemicals has been realized.

Opinions of Public Health Engineers

The chief public health engineers of the two states in which public water supplies have been affected by TVA activities have furnished statements, with permission to quote them. Their opinions have an objectivity which the authors of this article cannot hope to achieve:

When reservoirs are impounded, there are always certain problems that are presented in regard to the source when considered from a public water supply standpoint. The reservoirs impounded by the TVA are not exceptions. Tastes and odors have developed, thought to be as a direct result of these impoundments. The TVA authorities have shown an active interest in this problem, which concerns two or three of our public water supplies, and have made every effort possible toward locating the source of the trouble; it is firmly believed that once the trouble is found, which appears to be more of a reality at the present time than [at] any time in the past, [TVA] will do everything reasonable to make the necessary

corrections. We have always found the TVA authorities willing to cooperate in every way possible with the state in regard to impounded waters, with particular reference to public water supplies. Our contacts with the TVA engineers, particularly those connected with the Health and Safety Section, have been most cordial and we with the Alabama State Health Dept. feel free to call upon them for technical advice and aid.

Unless impounded areas are specifically for water supply, the general practice in the past [has been] to give little or no thought to water quality for use as a source of domestic water supply. It is conceivable that by the inclusion of water quality, consideration in the original planning could be of great value in future water supply operations.—*Arthur N. Beck, Chief Engr. and Director, Bureau of Sanitation, Alabama State Health Dept.*

As Sanitary Engineer with the Tennessee Dept. of Public Health, I have worked very closely with sanitary engineers of the Tennessee Valley Authority on matters relating to public water supplies and sewage disposal since the beginning of the development of the Tennessee Valley area within the state of Tennessee in 1933. In my opinion the policy of backwater adjustments in so far as the effect on physical structures was concerned has been very liberal. In several instances water supplies which were flooded out by impoundage were replaced with complete new systems including source of supply, intake structures, pumping and treatment facilities designed in accordance with modern engineering practices, thus giving the municipalities in most cases an improved water supply.

In most cases it has been found that water supplies utilizing the Tennessee River as a source . . . have not been adversely affected and in some instances an improvement in water quality has resulted. Although it is believed that the overall policy has resulted in an improved water quality in most instances under controlled flow conditions, it does appear that greater benefits would result through recognition of the value of maintaining higher minimum flows, particularly in areas where pollution is high. It is hoped that this point may be given more consideration in connection with the establishing of future policies.—*R. Paul Farrell, Director, Div. of San. Eng., Tennessee Dept. of Public Health.*

Summary

A review of public water supply experiences involved in the development and control of the Tennessee River system provides information that justifies thoughtful consideration by those concerned with the role of water supplies in resource development programs.

1. The TVA act does not specify that special consideration or priority be given to public water supplies.

2. The federal government is liable for compensation for all physical structures and properties damaged by its river development activities, with the exception of those located in the channels of navigable streams.

3. The government is not liable for consequential damages, such as deterioration of water quality, due to its activities unless a taking of property is involved.

4. The right of the government to develop navigable streams for navigation and flood control is paramount to the rights of all other parties.

5. Common sense and professional integrity played an important role in settlements made by representatives of TVA for damage to public water supplies resulting from its activities.

6. Thirty-three dams of various sizes provide integrated control of streams in the 41,000-square mile Tennessee River drainage basin for navigation, flood control and power production.

7. Public water supplies serving

only slightly less than one out of every six persons (15.6 per cent) in the valley have been affected in some degree by impoundage of streams.

8. The beneficial effects that have followed impoundage have outweighed the adverse effects on public water supplies. Undesirable effects have been felt by less than 2 per cent of the total valley population. The majority of these were affected by tastes and odors. Only 0.2 per cent have been faced with an acute public health problem.

9. Other effects include:

a. Beneficial—improved physical structures; more nearly constant stream flow; reductions in coliform organism concentrations, turbidity, alum requirements and chlorine demand; savings in the cost of chemicals; reduced fluctuations in characteristics; and increased simplicity of operation.

b. No change, or indefinite change—hardness, alkalinity, pH, color (concentration) and manganese.

c. Adverse—difficulty of coagulating and settling cold, clear water; difficulty of color removal; density currents; structures in navigable channels; and tastes and odors.

10. The scarcity of available information on which to base an evaluation of the impact of river system development on public water supply quality points to the need for more emphasis on the accumulation of reliable routine water plant operation data.

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Soil Pollution in the Potomac River Basin

By Harold A. Kemp

A contribution to the Journal by Harold A. Kemp, Director of San. Eng., Dist. of Columbia, and Vice-Chairman, Interstate Commission on the Potomac River Basin, Washington, D.C. This paper, in substantially the same form, has been published (1949) by the Interstate Commission on the Potomac River Basin, Washington, D.C.

THE term "stream pollution" immediately calls to mind pollution from domestic and industrial sources. This fact is a tribute to the long continued efforts of the sanitarian and conservationist. Most people now fully realize the great destruction of aquatic life and the menace to human health and welfare caused by these types of pollution. It is unfortunate that the same consideration and publicity have not been given to soil and natural pollution. Both have considerable effect on aquatic life and significant effect on the nation's health and welfare.

Two hundred years ago the Potomac River and all its tributaries were clean streams. All types of pollution were negligible in their effect on the quality of the water. During the next 100 years soil or mud pollution materially increased, but a study, reported in 1853, indicated that the Potomac River was suitable as a source of domestic water for Washington, D.C. Facilities were constructed and water from the Potomac River at Great Falls was delivered to the consumer in 1863. The turbidity of the water was never satisfactory but the people endured an ever increasing mud load for a period of about 40 years. The first filtration plant was placed in operation during 1905. There is now a clear, potable domestic water supply, but the cost of removing mud far exceeds all other costs in making the water suitable for use.

In 1948 the mud load of the Potomac River at Washington was 1,650,000 tons, as computed from turbidity tests made by the Washington Dist. of the Corps of Engineers. This figure does not include the bed load of heavier materials such as sand and gravel, which probably totals 200,000 tons. A conservative estimate of the average annual mud load of the river is 1,700,000 tons. It would be complacent to assume that this load results from stream bed erosion. The regimen or cross-sectional area of the main streams above Washington has not materially changed in 200 years. There is an actual loss of 30,000,000 cu.ft. of soil annually above Washington, equivalent to more than 1,300 acres or 2 square miles of 6-in. deep topsoil. Although the economic loss to agriculture is appalling, this discussion will be confined to the effect of soil pollution on aquatic life and on public health and welfare.

Effect on Aquatic Life

Except for certain types of bacteria and other microscopic organisms, all

life needs oxygen and nearly all forms of life require sunshine. A lack of oxygen means immediate death, and darkness means a shortened and withered life. Organic matter consumes oxygen and is present in all streams. Even a stream free of domestic or industrial pollution carries decaying vegetation and animal life. This organic matter is mixed with mud and settles to the bottom of the river, covering fish life in the spawn-fingerling stage. The organic matter consumes the oxygen present and the mud prevents reoxygenation. A large part of fish life in its early stages will be destroyed. Those fish which survive must face another hazard, consisting of turbid waters. Mud or silt in suspension will clog or cut the gills of many fish and mollusks. A turbidity of 3,000 ppm. is considered dangerous if sustained for a period of ten days. During the flood of 1936 the turbidity of the Potomac River reached 6,000 ppm., with excessive turbidity lasting fifteen days. The fish kill was large and the oyster beds were severely damaged. It has been estimated that the total mud during 1936 was nearly 5,000,000 tons.

The poor fish must still meet another major hazard from organic mud deposits and turbidity. Worms, protozoa, algae, insects and crustacea are injured or destroyed. All are important to the life cycle of the fish and some are essential for food purposes. The destruction of any single group of these lower forms of life may result in injury or death to higher forms of marine life. Perhaps the word "marine" should be omitted, for man himself may directly suffer. All life is interdependent.

High Treatment Costs

Any community which uses surface waters for domestic supply faces a real problem from turbidity. This observation is particularly true for Washington, where the summer consumption often exceeds 200 mgd. The raw water from Great Falls, which is about 10 miles above the District of Columbia, flows through twin conduits to the Dalecarlia Reservoir at the district line, where some of the heavier mud settles to the bottom. The reservoir is cleaned as needed. From there, after the addition of alum, water is conducted to two different filtration plants. The McMillan plant, completed in 1905, is located near the center of the District of Columbia and is of the slow sand type, with 29 filters totaling 29 acres of surface area. The filters must be cleaned on the average of two times yearly. The plant's rated capacity is 100 mgd. The Dalecarlia plant, completed in 1928, is located in the northwesterly part of the district near the Potomac River and is of the rapid sand type, with 20 filters totaling slightly over ½ acre. The filters must be cleaned, on the average, every two to four days, and the rated capacity is 85 mgd. To give a clearer idea of the size of these plants: it would cost over $30,000,000 to replace them. It should be kept in mind that they were built for the prime purpose of removing turbidity from the river water. Because of the exacting demands of the public for a clear water, they will never be abandoned. Furthermore, the sanitary engineer now realizes that the filtration process is extremely effective in removing harmful bacteria and minute organisms from the water. Just how, then, would a reduction in tur-

bidity benefit the users of domestic water?

Adequate soil conservation in the basin can reduce the turbidity of the river by over 75 per cent. The turbidity, for 95 per cent of the time, can be kept below 100 ppm. and probably below 25 ppm. for long sustained periods. During the 1936 flood turbidities reached 6,000 ppm., and on the peak day more than 1,500,000 tons of soil passed by the city; for the duration of the flood the total was over 3,500,000 tons.

It is staggering to think of the loss of over 60,000,000 cu.ft. of soil in a single flood. It would take a freight train 337 miles long to haul this load! Even with a turbidity as low as 100 ppm., water is not clear, as it contains 400 lb. of soil for each million gallons and a one-candlepower light disappears at a 12-in. depth. For the good of the basin as a whole, including the farmer and his successors, every effort should be made to reduce erosion and produce reasonable turbidity in the river.

If proper measures are taken, Washington will be able to reduce its cost of water treatment considerably. The savings in alum, lime and chlorine would total $34,000 per year at present costs and consumption; the savings in dredging of the reservoirs, another $12,000; and the cleaning of filters, at least $5,000. Exclusive of capital charges, the savings would be over $50,000 per year. It should be emphasized that the farmer will profit materially in making this saving available to the people of Washington.

Soil erosion has progressed to such an extent that vegetation is being washed into the streams and settles to the bottom along with the mud. This may cover and kill normal aquatic plant life. The decomposition of this mixture may impart decided tastes and odors to the water, which is difficult to treat. During February 1948 the people of Washington really suffered. Decaying plant life on the bottom of the river was covered for a period of about 40 days by a solid sheet of ice. Oxygen in the water was consumed and new oxygen could not be absorbed from the air. When the thaw occurred, the ice floes scoured the river bottom and a musty taste and odor were imparted to the water. Filtration plant capacities were not large enough to secure adequate control.

Dredging Expense

The Potomac River is navigable up to the city of Washington and must be kept open to traffic. Above Washington, the river is rapid, and even the heavier sands and gravel are gradually forced downstream. When the flow reaches the wider, deeper and flat river it is slowed and the material drops out of suspension, the heavier in the vicinity of Washington, the lighter even reaching the ocean. At least 90 per cent of the silt is deposited in the river. The bottom is being raised and sometime extensive dredging must be undertaken. Even now it is necessary to remove about 150,000 cu.yd. of silt each year from the river in the metropolitan area in order to maintain navigable depths in the deeper parts of the river farther downstream. It has been estimated that a saving of $60,000 per year could be made at the present time if turbidities could be reduced to 100 ppm. Future savings are problematical but could be many times greater.

Natural pollution is usually considered the result of the normal process

of growth and decay of plant and animal life on land and in the water, domestic pollution excepted. When soil erosion progresses to such an extent that bushes and even trees are washed into the stream, natural pollution should be regarded as part and parcel of soil pollution. The Potomac River, particularly the stretch between the Monocacy River and Washington, is no longer a river of unmarred natural beauty. In the stretch between Key Bridge in Washington and Great Falls, the rocky bottom at elevations higher than the normal stream bed is covered with mud, silt and debris of all sorts, even including parts of farm buildings and equipment. The true aesthetic value is destroyed and the metropolitan area suffers a real loss. Farther downstream, in the tidewater reaches, coves, bays and creeks are being marred and converted into mud flats. Many sections are being filled in on account of their unsightliness, to the detriment of the river's recuperative power in the assimilation of pollution.

Another of the major adverse conditions created by soil pollution is the filling in of harbors. Many important early settlements in Maryland and Virginia lost their value for the simple reason that ships were prevented from docking. Examples include Bladensburg on the Eastern Branch of the Anacostia River, Piscataway on Piscataway Creek, Port Tobacco on Port Tobacco River and Dumfries on Quantico Creek. Unless expensive dredging is maintained, Washington will lose its value as a port.

Soil Conservation and Floods

To date there has been no indication of a decline or even leveling off of the amount of soil in the river. The decreasing cover and increasing erosion are releasing more and more water to streams during storms, lowering the normal ground water table where water is sorely needed during sustained droughts and raising the height of peak floods downstream where physical damage may be inflicted by inundation. The District of Columbia has adequate protection against floods of the magnitude of 1936, but other communities may not be so fortunate. A superflood would create real trouble, particularly in various areas upstream. The adequate use of soil conservation methods will probably lower the peak stage in the Washington area by about 1 ft., and upstream, in the vicinity of Point of Rocks, by about 3 ft. Costly cleanup operations in the removal of mud and debris would be considerably lessened.

Conclusion

This paper has only touched the high spots, but everyone with a little imagination can picture the adverse results of continued uncontrolled soil pollution. Just compare today's conditions with those reported by Father White, a missionary to the Indians, back in 1634:

> This is the sweetest and greatest river I have ever seene, so that the Thames is but a little finger to it. There are now marches or swampes about it, but solid firme ground, with great variety of woode, not choaked up with undershrubs, but commonly so farre distant from each other as a coach and fower horses may travele without molestration. The soyle is so excellent that we cannot sett down a foote, but tread on strawberries, raspires, fallen mulberrie vines, acchornes, walnutts, saxafras, etc., and those in the wildest woods. The ground is commonly a black mould above, and a foote within

ground of a readish colour. All is high woods except where the Indians have cleared for corne. It abounds with delicate springs which are best drinks. . . .

If the present rate of erosion continues, here and throughout the world, it will be impossible to replenish the losses, making the ultimate outcome a very dismal prospect. Erosion can and must be reduced to reasonable limits so that nature and man can keep step with this destructive force. The District of Columbia realizes that it must cooperate with agricultural interests for its own protection against the cause and effects of wasted soil. It is now planning facilities which will cost over $1,500,000 for the purpose of making its sewage sludge economically available to the farmer as both a humus and a fertilizing material.

The author has endeavored to point out that the inhabitants of the Potomac watershed are face to face with a condition which, if left uncontrolled, will continue to deplete the natural resources of the area and, as conditions become progressively worse, will have an increasingly adverse effect upon future generations. It is gratifying to see those confronted with similar problems in other sections of the country awakening to the realization that they must do something constructive to protect the nation's welfare. Situated in one of the most fertile spots in the United States, with the nation's capital on the banks of the most important stream of their watershed, it behooves the people of the Potomac region to do all in their power to undertake corrective measures.

Erratum

As a result of an oversight, an omission occurred in one of the illustrations for the paper by Malcolm S. McIlroy, "Pipeline Network Flow Analysis Using Ordinary Algebra," which appeared in the May 1949 JOURNAL (Vol. 41, p. 422). In Fig. 3, the graph showing error in head loss approximation on p. 427, the upper sloping line should have been labelled "$n = 2$," and the lower line, "$n = 1.85$."

For readers desiring to make this correction in the article, the corrected graph is reproduced on p. 10 (P&R) of this issue.

The British Water Industry

By N. F. S. Winter

An address delivered on June 1, 1949, at the Annual Conference, Chicago, by N. F. S. Winter, Chairman, Halifax Corp. Water Committee, Halifax, Yorkshire, England.

I COUNT it a distinct honor that you should have invited me to attend your Conference. It is more, it is a gracious compliment to my colleagues in Great Britain.

It is, I believe, the first time a representative of the British Waterworks Assn. has attended your congress. That I should be that representative is a great privilege, more especially as this is the occasion you had selected for conferring a very high honor on one of our most distinguished members.

I refer, of course, to Mr. Henry Berry, the Immediate Past President of the B.W.A., a member of Parliament, and for nearly a quarter of a century a member of the great Metropolitan Water Board.

Mr. Berry and I are members of different political parties. His party is in power at the moment; mine, for a short while, is out; but we are great friends and good colleagues. He comes from the great metropolis, I from the industrial part of Yorkshire. We are both Past Presidents of the B.W.A., and have been members of the Executive Board for many years. We are both members of His Majesty's Central Advisory Water Committee—set up by the goverment to advise it on water supply problems.

We have much in common, so that you will realize how greatly disappointed I was when I received a letter from your Secretary, the day before I sailed for Canada, informing me of Mr. Berry's inability to make the trip and asking me if I would present his paper. I am sure everyone in this hall shares, with me, that disappointment; for the man you had thought fit to honor is a delightful personality and a witty speaker.

I had a talk with him just before I left England, and he wished me to convey to you his great regret at not being able to be with you, and his best wishes for a successful conference. He promised to mail the transcript of his paper to me in Canada, but unfortunately it did not arrive, a fact which must be a disappointment to you all; and so it falls to my lot to fill the breech as his deputy. Not having the slightest clue as to what line Mr. Berry would take—for this is in no way a joint paper—and having had practically no time for preparation, I have decided to give a general talk on water supply in Great Britain.

First and foremost in this matter of water supply, we are, no doubt like yourselves, particularly alive to the problems of the prevention of pollution and of constantly increasing consumption.

In a densely populated island, where some 48 millions of our population of

50 millions have a piped water supply, and with a rising standard of consumption, the problems of safeguarding the purity of supplies are bound to be difficult.

During the war the minister of health issued an edict making it compulsory for water undertakers to chlorinate their supplies, although in the case of many undertakings where supplies are drawn from the uplands, especially in the case of my own undertaking in Yorkshire, the supply at the source is of such a high degree of purity as to render this unnecessary.

This edict is still in force, and, in addition to chlorination, practically all the large undertakings have installed water treatment plants, many of these of the most modern high-pressure type.

At the moment in England, where, unlike you on this vast continent, we have no large lakes or huge rivers and where we have to rely for supplies upon the dammed valley streams in the highlands, and a few rivers and underground sources in the plains, we are threatened with a serious shortage. This has been occasioned by the fact that there has been a steady increase in consumption of up to 10 gpd. per capita in the last ten years, and owing to the war the construction of new works to meet that extra demand has almost been at a standstill.

In the areas of well supplies under the 1945 Water Act, we have evolved controlling legislative machinery for districts where overpumping of underground supplies is likely, consisting of a system of licensing further extractions of water.

In the areas which rely on upland sources, we developed in the half century after 1875 a system of acquiring large areas of gathering grounds and controlling access and types of agriculture so as to ensure the maintenance of the purity of water.

The pressure of population has necessitated a review of that problem. One of the most urgent questions which the undertakers are having to consider is the demand by certain sections of the population for access to the gathering grounds of water undertakers. The problem is a difficult one and must be looked at in the light of the circumstances of the country as a whole.

There is an urgent need for enlarging agricultural production. There is an urgent need for the afforestation of increasing areas of land. There is an urgent need for healthy exercise and recreation by many of the people in towns. There is an urgent need to maintain the purity of the sources from which the great cities draw their water. It is no light task in such circumstances to have to decide what is the true interest of the nation.

There is a bill now before Parliament which is dealing with access to open spaces generally and it would not be right for me at this stage to say what legislation will finally be put upon the statute book, nor what will be its effect upon water undertakings situated, as is my own, in the uplands and highlands of our country.

In my country, and it may also be true of yours, few if any of the people are interested in water supply as long as it is available, but the problem of bringing more and more water to an ever growing thirst is indeed likely to bring itself to their notice if we in the water industry do not, within the next few years, increase our reserves and carry out the urgent works which have been delayed by the war.

As regards the future of the water

industry in Great Britain, while it is true that the Labour Party has included the question of nationalization in the program for the congress which is being held at this moment, I doubt if there will be any great change in the future setup.

Of the 1,000 water undertakings in the country, the 125 largest supply some 75 per cent of the population, leaving some 800-odd of the smaller undertakings to supply the remaining 25 per cent. It is clear that these smaller undertakings cannot possibly be efficiently administered, obviously on account of the fact that their finances are relatively small and it is not possible to engage a properly qualified staff or employ up-to-date methods.

Realizing this difficulty, the government commenced a survey of the water resources of the country some three years ago, with a view, no doubt, to regionalization, and in this way the smaller undertakings would be absorbed in the larger to the mutual benefit of both. This survey is now almost complete, and, very probably, joint boards will be set up in the near future, with representation proportionate to the size of the various undertakings comprising the board.

It must be appreciated that while the various undertakings are self-administered, they are nevertheless to a certain extent controlled by the minister of health under the Water Works Clauses Act of 1847 and the Water Act of 1945. About one-third of the undertakings are owned and administered by the municipalities; another third, like the Metropolitan Water Board, by joint boards; and the remainder, by companies. So far as the two former groups are concerned, they are not allowed to make any profit or show a loss. To achieve this end, the water charges are subject to review at definite fixed periods—sometimes three years, sometimes five. In like manner, the companies are controlled in so far as the profits they are allowed to make are concerned and also in the matter of issue of stock.

It will be seen, therefore, that, with the government already having so much control, there is little need for full nationalization.

I feel that the industry will be regionalized, and this, to my way of thinking, will be an improvement on the present setup.

May I say a word or two regarding the newly formed International Water Supply Assn., of which body I had the honor to be elected the first president, preliminary to the first real congress, which is to be held in Amsterdam in September 1949.

It has been noted that your Association has not found it possible to be with us in this work, and, while we appreciate your reasons, we have great need of your help.

It may be that, from our experience gained in organizing this first congress, we shall have to limit congresses to one in every five years, and meetings of the executive board to one each year. It is clear also, that the organization of the congress must be left almost entirely in the hands of the country within whose borders it is to be held.

It is essential that the practical working of the organization shall, first, make it easy for all who are interested to join and play an active part in the organization; and secondly, that the financial burden, both by way of subscription and the cost of traveling to meetings, shall not be so great as to

render the efforts of those interested nugatory.

I believe that the great American water industry, which has, perhaps, more than that of any other single nation to contribute to this sphere of work, will not, in the long run, let my plea made on behalf of a large number of countries go unanswered.

It is my pleasure and privilege to convey to you greetings and good wishes from the B.W.A.—representing some 600 authority members scattered throughout the British Empire. I am indeed honored by the invitation to your most hospitable country and I am sensibly impressed by your kindly reception of me, by your overwhelming generosity and by the fine spirit that is abroad in your land.

I was about to say that this is my first visit to America and while it is true that I have never previously crossed the Atlantic I have on many occasions been on friendly American soil.

On the way from my club to the offices of the B.W.A., I have to traverse Grosvenor Square, perhaps the finest of our many London squares—which was dedicated to your great nation—where the grass throughout the season is as green as the memory of one of the greatest statesmen of our time, for whom we have a deep and lasting affection.

Over the last century you have made a wonderful contribution to civilization, especially in the progress you have made in the field of water supply. In the wider field you have made a still greater contribution during the war, which considerably enhanced the close friendship already existing between the peoples of America and Britain—a common bond of interest which has been greatly strengthened by your most generous assistance in our postwar period of difficulty.

We are deeply grateful for that assistance, and, although we are living a life of austerity, we are doing so with good grace in an earnest endeavor to stabilize our position so that we can enjoy the standard of living to which, for many centuries, we have been accustomed.

We English-speaking peoples have much in common—your ways are our ways—our love of country, of home and of our fellowmen and our peaceful way of life are the same in spite of the strip of sea that divides us.

Our literature and our language have a common root. That is an advantage which it is impossible to overestimate. It makes it so much easier to avoid misunderstanding. It makes it so much easier to work together. It is so much easier for us to see the "other man's" point of view, for we speak the same language and have the same kind of thoughts.

In the world of water supply we shall not be competing. It may be that we shall be able to develop an exchange of ideas, and that the development will be of advantage to the rest of the world.

In the greater world, our roots, our language and our attachment to common ideals are certain to make us march together, through the years to come, seeking the betterment of human life.

Diatomite Filters for Swimming Pools

By John E. Kiker Jr.

A contribution to the Journal by John E. Kiker Jr., Prof. of Public Health Eng., Univ. of Florida, Gainesville, Fla.

IN the treatment of water of low turbidity, diatomaceous earth filters can be used without the addition of coagulants. They also require less area than conventional sand filters. The first multi-unit installation of diatomaceous earth filters for water clarification in Florida is located at the University of Florida swimming pool. The Florida State Board of Health does not at this time give blanket approval to diatomite filters, but it encouraged the present installation with the understanding that the university would cooperate in determining the operating characteristics and weaknesses.

The installation was completed during the summer of 1948. At the request of the state sanitary engineer, tests were undertaken as a research project of the Florida Engineering and Industrial Experiment Station.

Description of Facilities

Figure 1 is a flow diagram or piping layout of the installation. The pool, with a capacity of 500,000 gal., was constructed approximately twenty years ago, which may account for the filtered water inlets being located on the bottom of the pool. This method of distribution, however, can be made reasonably satisfactory. Compared to the more orthodox method of applying recirculated water through submerged inlets around the periphery of the pool, it has both advantages and disadvantages.

Water from fourteen scum gutter drains is recirculated through three SW–80–E Stellar Filters,* each having a total of 62 septums or filter elements and a total filter surface area of 80 sq.ft. The three filters, with a total area of 240 sq.ft., were designed to operate at 4 gpm. per square foot while recirculating 960 gpm.

Each filter was initially equipped with a diatomite charging funnel for use in applying precoats of diatomite to the filter elements. Measured quantities of the diatomite were simply placed in a pail, mixed with water being drawn from a tap, and poured into the funnels. In order to eliminate the necessity of lifting the heavy pails, the filter operator recently replaced the three funnels with a single charging drum located upon a platform where the diatomite is stored. The mixed charge is now piped from the drum to the filters through the connections formerly used for the funnels. This facility has added materially to the convenience of operation and has not in any way affected the results.

In addition to the charging drum, a so-called "Hi-Cap Feeder" * is available for applying diatomite or other filter aids during the filter runs.

* Manufactured by Infilco, Inc., Chicago.

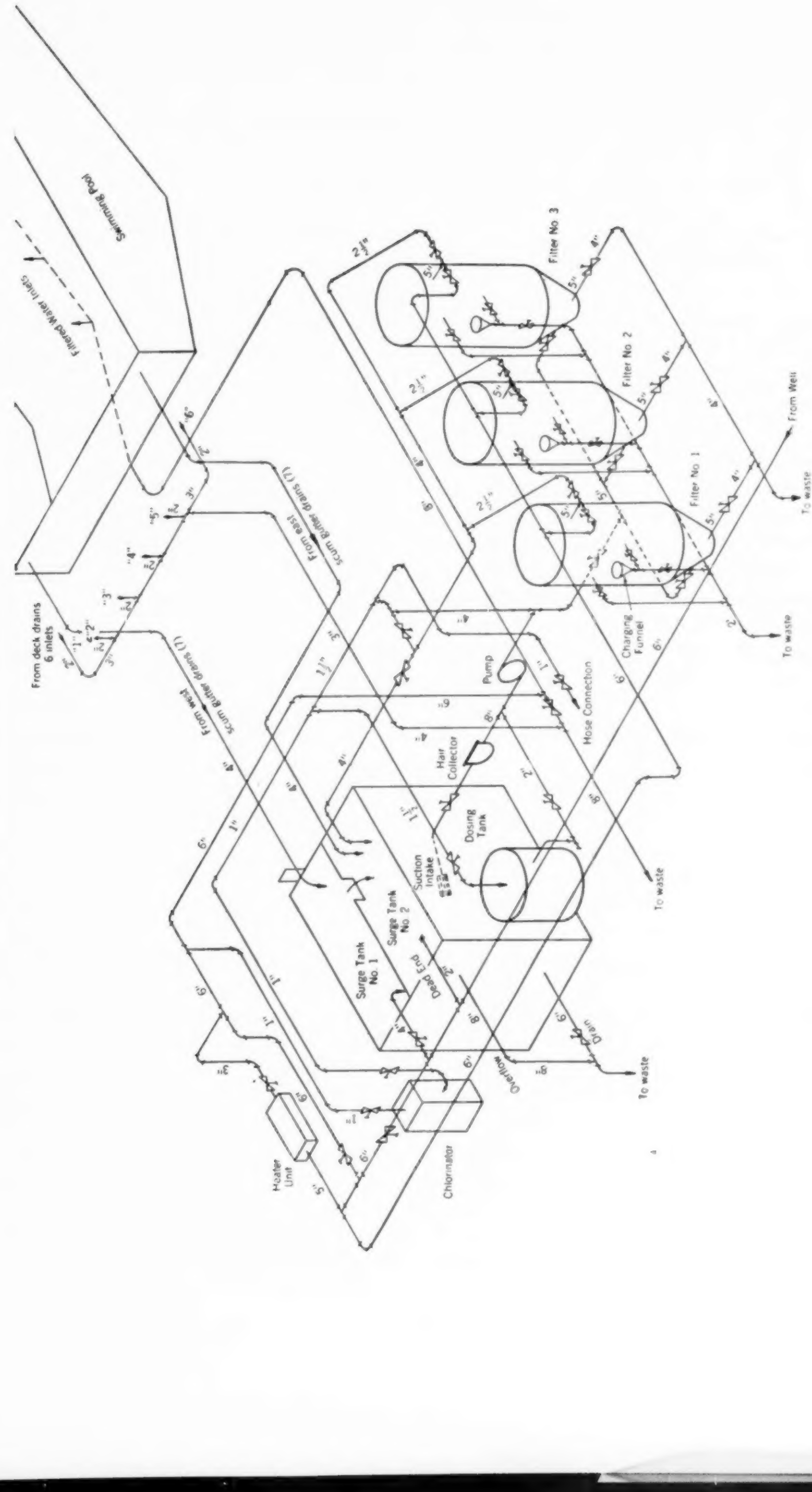


FIG. 1. Piping Layout

Test Procedures

The principal purpose of a swimming pool filter is to remove turbidity from the water being recirculated through the pool. The removal or destruction of bacteria is the purpose and function of chlorination. Tests were made, however, to determine the efficiency of the filters in removing both turbidity and bacteria under different conditions of operation. Tests were also made to compare the lengths of filter runs with and without continuous applications of the filter aid. In addition, the filters were purposely subjected to the kinds of abuse that might accompany negligent or incompetent operation. For example, the filters were overloaded on several occasions. They were shut down without backwashing and permitted to remain in this condition for prolonged periods. Repeatedly the filter cake was suddenly dropped from the filter elements and the rate of recovery observed. The application of chlorine was discontinued and algae growths were permitted to develop in the pool.

Prior to the start of the tests, the rate of recirculation had been set at 750 gpm., and the filters were operated over a period of nine to ten hours daily. With the light bathing loads that prevailed—150–200 persons a day —these conditions had been found adequate to maintain water of excellent clarity and quality in the pool. Operations during the tests were limited to the recirculation rates in use before the experiments were started, which had the advantage of preventing any interference with the routine duties of the pool operator. The filtration rates were increased 50–200 per cent, however, by cutting one or two of the filters out of operation.

The filter aid used throughout the experiments was Celite 545, the coarsest grade of diatomite produced by Johns-Manville. No coagulants were employed. Briquets of soda ash were occasionally added when necessary to keep the pH around 7.6. Other than chlorine, no algicide was used during the tests.

Results of Tests

The data obtained during the tests are too voluminous to include in their entirety. The following is a summary of the more important observations and results, however, with charts showing some of the data that were amenable to graphical representations.

Turbidity Removal

Throughout the tests, the filters were practically 100 per cent efficient in the removal of turbidity from the recirculated water. The turbidity of the filter influent ranged from less than 1 to approximately 20 ppm., depending upon the amount of diatomite added continuously to the water and the amount of algae that had been permitted to develop in the pool. Without exception, during the period of the tests, the turbidity of the filter effluent was reduced to zero within 60–90 seconds after the filters had been placed in operation. Precoat dosages of diatomite varied from 1.2 to 8.4 oz. per square foot. Continuous-feed dosages varied from zero to approximately 2 oz. per square foot per hour. Within these ranges, the turbidity removals were independent of the dosages. For removing turbidity, a precoat of 2.4 oz. per square foot, without continuous feed, was as effective as a precoat of 8.4 oz. per square foot. Likewise, a precoat of

1.2 oz. per square foot plus a continuous feed of about 0.2 oz. per square foot per hour was as effective as a precoat of 6.7 oz. per square foot plus a continuous feed of about 2 oz. per square foot per hour.

On numerous occasions the coating of diatomite was released suddenly from the filter elements by opening air relief valves in the tops of the filters. In addition, the filters were shut down and started up again without filtering to waste while the precoat was reforming. Such tests are perhaps as severe as any that might be given. The operations led to sudden increases in turbidity and resulted in the entrance of improperly clarified water into the effluent lines. The water became crystal clear within 30–90 seconds, and increases in the turbidity of water within the pool were not appreciable. The exact time required for the water to clear up depended upon the rate of filtration and the amount of diatomite in the filters. The higher the rates of filtration, and the larger the amount of diatomite that had settled when the air was released and the coating dropped, the shorter was the time required for the water to clear up.

These results are believed to answer the objection that diatomite filters may be unsatisfactory for swimming pools because of the effects of interruptions due to power failures. In any event, the objection can be readily overcome by proper wiring systems or by installing pumps which have to be restarted manually once they have stopped because of interruptions in electric current. This will give the operator an opportunity to filter to waste when restarting the pump.

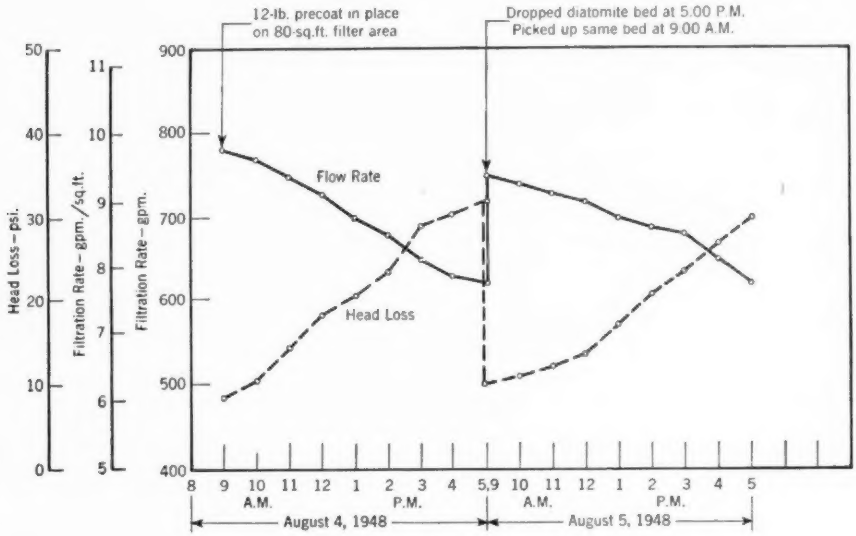


FIG. 2. Filter Data, Aug. 4–5

Bacteria Removal

In order to determine the efficiency of the filters in the removal of bac-

teria, the application of chlorine was discontinued for a period of five days during one series of tests. The removal of bacteria by the filters varied from zero to 96 per cent. Bacteria counts in samples from the pool were negligible, however, when there was a free chlorine residual in excess of 0.2 ppm. Coliform indexes followed the same general pattern as the bacteria counts. Tests for coliform organisms were generally negative in 100-ml. pool samples whenever there was a chlorine residual. The samples were collected in bottles containing requisite amounts of lactose broth.

In general, efficiencies in removing bacteria improved with increased head losses through the filters. This should not, however, be interpreted as a recommendation favoring high head losses, since filters are installed to remove turbidity rather than bacteria. As previously explained, disinfection is accomplished with moderate dosages of chlorine.

Body Feed and Head Losses

Tests were run with and without diatomite body feed to determine the effects of continuous feeding upon head losses through the filters at filtration rates approximating 3, 4.5 and 9 gpm. per square foot. The results are shown graphically in Fig. 2–4. It appears that at the higher filtration rate head losses were reduced appreciably by feeding the diatomite slurry. At the lower rates, body feeding had no appreciable effect during these particular tests. In another series of tests, however, when chlorination was discontinued long enough to permit accumulations of algae and other organisms, head losses built up so rapidly that continuous feeding of the filter aid was necessary in order to obtain filter runs of reasonable lengths. Although the results are not conclusive, since they represent only limited combinations of body feed and precoat, the following comments are believed justified:

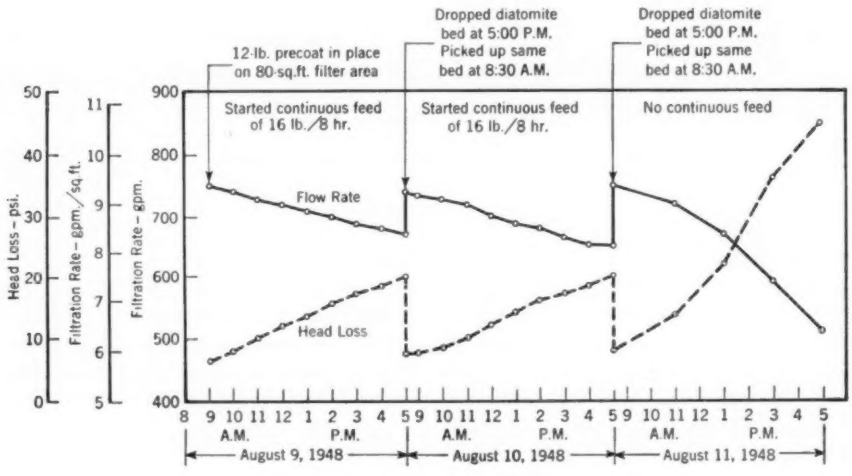


FIG. 3. Filter Data, Aug. 9–11

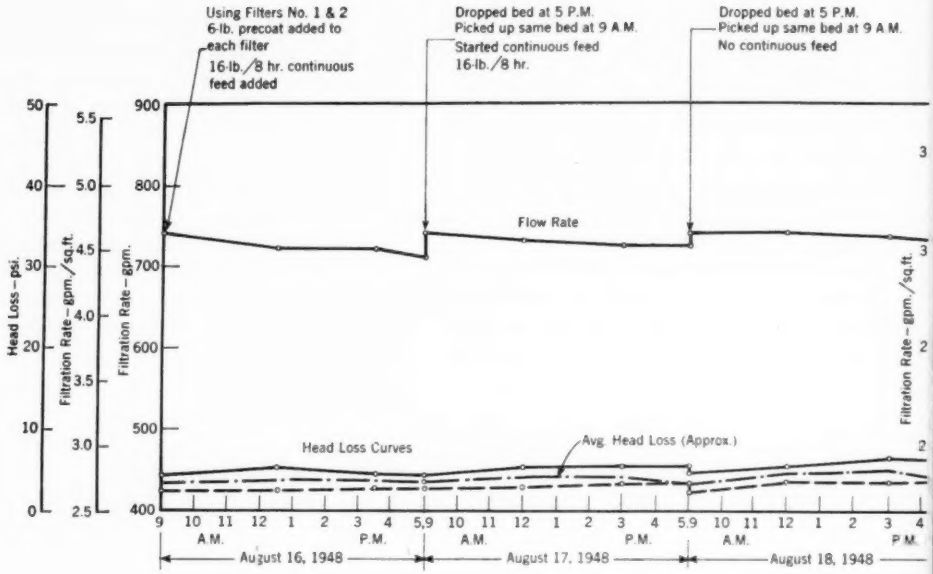


FIG. 4. Filter

1. Body feeding is not necessary at the University of Florida installation when filtration rates are low and when the chlorine dosage is high enough to obtain a free residual above 0.2 ppm.

2. Body feeding may be desirable at high filtration rates. It is unquestionably desirable where algae growths have been permitted to develop and where high turbidities are encountered.

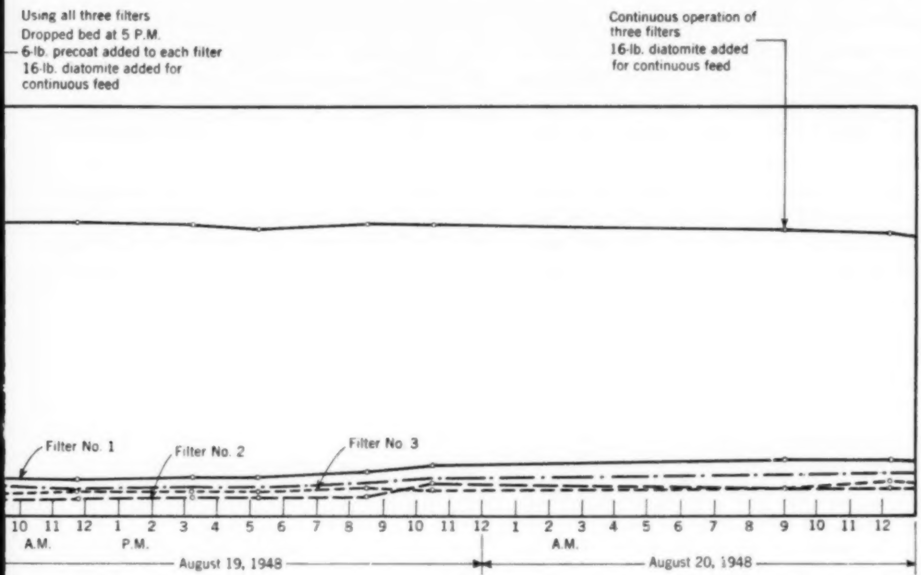
3. Since the number of diatomite filter installations are relatively few, and present knowledge of their characteristics is necessarily limited, each new installation should be studied individually and the cost of adding diatomite continuously should be compared with the possible savings in power consumption before reaching a decision on whether the body feed should be used routinely.

4. As the cost of the diatomite filter aid is a major item of expense in the operation of diatomite filters, and as the amount used can be appreciably reduced by operating at low filtration rates, the savings which may accrue through operation at the lower rates may more than compensate for the cost of an extra filter to reduce the rate.

5. The indication that the cost of operation may be reduced by eliminating body feed is a point in favor of diatomite filter installations. Such reductions in operating costs will permit diatomite filters to compare more favorably with rapid sand filters.

6. A filtration rate of 3–4 gpm. per square foot is low enough for the conditions prevailing at the University of Florida swimming pool. A filtration rate approaching 9 gpm. is much too high.

7. Additional information and research are needed before categorical



a, Aug. 16–20

statements as to whether body feed will pay for itself at any given installation can be justified in advance. For the present, provision for body feed should be made at most pools where diatomite filters are installed.

Reuse of Diatomite

On six different days diatomite which had been used on previous days was reused without treatment of any kind. The filter cake which had been dropped from or blown off the elements when shutting down the previous day was simply picked up and employed as a precoat when operations were resumed. On one occasion the material was used and reused during three days of operation. Results were not noticeably impaired by this procedure. The filtered water and the water in the pool still met the U.S. Public Health Service Drinking Water Standards when the chlorine residual was 0.2 ppm.

The effects of reusing diatomite without disinfection cannot compare with the effects of permitting the recirculated water to pass through a hair catcher that is not properly cleaned. (When chlorination was temporarily discontinued in this particular installation, the water picked up as many bacteria during its passage through the hair catcher as were contributed by the bathing load.) It is apparent, however, that the reuse of any filter aid should not be permitted unless a good free chlorine residual is maintained in the recirculated water.

Operation

Some sanitary and public health engineers have built up a resistance to the acceptance of diatomite filters, even for swimming pools, due in part

to advertisements to the effect that the filters can be easily operated by unskilled persons. The tests indicate that in some respects diatomite swimming pool filters are simpler to operate than sand filters. Coagulants are not required. Filtration rates may be varied 100 per cent or more without reducing the clarity of the effluent. Backwashing does not have to be performed so carefully. Efficiency of filtration is not reduced by excessive head losses; if anything, the clarity of the effluent is increased.

Diatomite filters have these and other advantages, but they are not foolproof. They require about the same degree of skill and attention as sand filters do, and they are just about as easy to abuse. It is believed that a person who would not follow instructions in operating an ordinary sand filter would not follow the instructions necessary for the proper operation of a filter employing diatomite as a filter aid. For one thing, the failure to backwash or blow off the filter cake at the end of each run will lead to premature clogging of the filter elements. The filter elements should be thoroughly backwashed before being permitted to stand idle overnight.

Other claims for diatomite filters seem incompatible or contradictory. One manufacturer claimed eight days' operation between washings. Another stated that filter runs between cleaning operations are relatively short, but that this is satisfactory because of the ease of rebuilding the filter cake and returning the filter to service. Since the lengths of filter runs may depend upon the rate of filtration, as well as the amount of diatomite used, the size or type of filter aid, the characteristics of the raw water, the "slime factor" of the suspended solids and perhaps other factors, it is quite understandable that there will be wide variations in the lengths of runs. To say that short runs are generally satisfactory, however, is believed incorrect. Short runs are incompatible with the alleged convenience of operation. The shorter the runs, the more frequently the filters have to be visited and backwashed. This fact is important when an operator has many other duties. One of the virtues of diatomite filters, however, is that they can be operated at different rates. It is particularly advantageous to be able to step up the turnover by increasing filtration rates on holidays or during peak bathing loads.

It was noted during this investigation that the filter cake formed more slowly around the elements where the flow of water was most rapid. These observations suggest that the elements should be precoated very slowly, although this point is questioned by engineers who have worked with filter aids in the chemical industry. There was also some indication that a perforated baffle near the bottom of the filter, above the inlet, might aid in preventing currents and obtaining better dispersion of the incoming water and the filter aid.

Summary and Conclusions

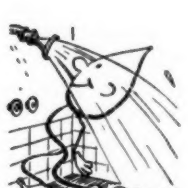
From the experience to date at the University of Florida swimming pool, it is believed that diatomite filters offer many advantages for swimming pool installations where the water being recirculated has low turbidity. It is also thought that the operational and experimental data now available are sufficient to warrant the acceptance of diatomite filters for swimming pools

on the same basis on which rapid sand gravity or pressure filters are approved. As with sand filters, however, competent operation should be made a condition of the approval.

Much additional experimental work remains to be done before definite recommendations can be justified on some of the operating procedures and on some features of design. Such work is to be continued as a project of the Florida Engineering and Industrial Experiment Station. The next experiments will be on a finer grade of diatomite and on other types of filter aids.

Acknowledgment

The tests and experiments herein described were made at the suggestion of David B. Lee, Chief San. Engr., Florida State Board of Health. Many helpful suggestions were received from him and from several members of his staff. Grateful acknowledgment is made for the encouragement and help received from R. A. Morgen, Director, Florida Engineering and Industrial Experiment Station, and from C. D. Williams, Head Professor of Civil Engineering, under whose respective jurisdictions the experiments were conducted. Similar encouragement was received from Coach Percy M. Beard and Coach F. D. Genovar, who have charge of the pool. Much help was also received from W. I. Bellew, swimming pool operator. Most of the tests were made by John C. Seeger, D. D. Gold, D. E. Barry and M. E. Dawkins, graduate students in sanitary and public health engineering. The filtration system was designed by Newton C. Ebaugh, Head Professor of Mechanical Engineering, who made liberal contributions of plans and old records of interest.



Advantages and Limitations of Automatic Equipment

By Vance C. Lischer

A paper presented on June 2, 1949, at the Annual Conference, Chicago, by Vance C. Lischer, Cons. Engr., Horner & Shifrin, St. Louis.

IMPROVED methods of processing and manufacturing have been the primary reasons for the large increase in the amount of goods and services each succeeding generation is able to enjoy. These improved methods have brought lower costs of production, have made higher wages possible and have resulted in lower costs to consumers.

In the water works field, improved methods have been responsible for higher quality of product and service, and above all during the current inflation have made possible the continuance of service without increases in cost to the customer commensurate with the general increase in cost of practically all other commodities. When automatic control can be shown to be an "improved method" for any particular unit in a water works system, it should be adopted if it results in lower overall costs or in a needed improvement in water quality or service.

This paper will give some of the advantages and limitations of automatic control and review some of the processes and equipment used in water works which are amenable to successful automatic control.

Although it might seem unnecessary to do so, there is a need for defining what is meant by "automatic control." Automatic means self-acting; hence it is implied that a manual operation has been eliminated. The use of the term "automatic," with respect to specific processes, of necessity varies. To a person who dips water from a spring and carries it to his house in a bucket, any pump is automatic even if it has a pump handle which must be worked to make it lift water. A power pump manually started and stopped would be the ultimate in automatic control to such a person. Yet pumps are not now considered by engineers to be automatic. Practically all power-driven machinery, when first introduced, was regarded as automatic if it reduced or eliminated manual labor.

A reasonably accurate definition of "automatic control" might be: a process or device which eliminates or reduces *necessary* manual effort. The word "necessary" is essential to the definition. Wasted time should not be tolerated in any plant. The conservation of effort and skill by the use of automatic control will make possible future social and economic gains.

Many automatic devices are essential because their performance cannot be matched by manual effort regardless of the quality of personnel. The filter rate controller is one of these. Continuous chemical feeders perform functions which manual effort cannot duplicate at reasonable cost. Liquid level controls, pressure-reducing valves,

thermostats, draft regulators, speed governors all perform service that manual effort cannot equal.

In rendering service to others, there are two viewpoints as to what is automatic—that of the purveyor of service and that of the user. For example, the dial telephone is a remarkable automatic development from the standpoint of the purveyor of the telephone service, yet it makes less automatic the initiating of a call. The dictaphone is automatic from the standpoint that it eliminates dictation-taking from a stenographer's work, but it requires additional work on the part of the person giving dictation, particularly if he wishes to make a correction.

Consideration must always be given to the overall effect when an automatic device or process is planned. The quality of service to the customer must be considered first. If reductions in both cost and quality of service to the customer result from the automatic control of a unit, then, in balancing lower quality of service against a saving in cost, the viewpoint of the customer must be given thorough study.

Control Links

Automatic control necessarily involves a measurement and a regulation which are performed by separate devices. From the measuring device to the regulator there must be a connecting link, which can be mechanical, hydraulic, pneumatic or electric. The range of application of the various means of connecting the measuring and regulating devices depends largely on the distance limitations of the links.

Mechanical links are necessarily limited to the practical distance for running cables or connecting rods, perhaps 50 ft.

Hydraulic links are limited by the type of fluid which must be used and by the characteristics of the control, particularly the rate at which fluid must be transmitted when the control is functioning. Friction loss may restrict the use of this method to distances of about 200–500 ft. The use of water as a fluid imposes limitations in cold climates because of the possibility of freezing.

Pneumatic links are practical up to about 1,000 ft. Because of the low friction loss, small-size piping is practical. Generally, ¼-in.-od. copper tubing is sufficient. With adequate drying facilities on the air supply, no cold-weather problem is encountered.

The types of electric links are numerous. They are suited to distances from a few feet up to, if necessary, a thousand or more miles. The type which is used will depend on the distance and economic considerations in providing the communicating channel. Several of the most important types of electrical interconnecting links useful in water works practice are reviewed below.

Direct electrical interconnection. The simplest means of electrical control is using the circuit actuating the regulating device directly in the measuring unit. In this class would fall, for example, the use of a float switch or thermostatic switch for carrying the full motor or heater current. It would also include arrangements in which the coil circuit of the starter or contactor is directly connected to the measuring device. Such a direct means of control is generally limited to 500–1,000 ft.

Self-synchronizing generators and motors. Self-synchronizing generators and motors transmit a motion from one point to another. These relatively simple devices bear the trade names,

"Selsyn,"* "Synchrotie"† and "Elinco"‡ motors, and require single-phase 110- or 220-v. exciting current of the same phase angle at each location, plus three connecting wires. If exciting current of the same phase angle is not present at both locations (which is the more common instance), five connecting wires are required. The relatively large number of wires and the character of the circuits required limit the application of these devices to distances up to 5 miles.

Time impulse. In the time impulse method, the magnitude of the function being transmitted—whether flow, temperature, pressure or depth—is transformed into a time impulse. The duration of the impulse is a measure of the magnitude. The cycle of the time measurements can be varied to suit the characteristics of the particular function being measured. The time impulse can be transmitted once in 60 or 15 seconds, and, if necessary, as frequently as once a second. The longer time impulses are not suited to rapidly fluctuating measurements but are well adapted to transmitting distribution system pressures and rates of flow. The most common types of time impulse transmissions require regulated-frequency a-c. power at both ends of the system, but they can be made to function with the regulated power at one end only.

The system requires two interconnecting wires, which can be a leased telephone channel, making the method readily available at relatively low cost. The distance of transmission is limited to about 40 miles where repeater stations are not used. There is no distance limitation when repeater stations are used, as is true with leased telephone service. By utilizing contact-making receivers, such automatic functions can be performed as, for example, the closing of valves or the starting and stopping of pumps.

This system is not affected by moderate variations in resistance or impedance of the connecting lines, or in the strength of the impulse. The system can be used for transmitting a number of different measurements over the same pair of wires by using the wires only a part of the time for each measurement. Where the function is subject only to gradual change, this is no disadvantage. The use of one pair of wires for several measurements makes possible a considerable saving, especially when telephone channels are leased. By using several frequencies, a large number of measurements can be made over the same pair of wires. However, if these are leased telephone wires, the rate for service is based on the number of frequency channels used. Carrier current channels and radio transmission can also be used.

The trade names "Chronoflo" § and "Metameter" ‖ are associated with time impulse transmission devices now available. The Leeds-Northrup Co. also manufactures such devices.

Telephone signal. The telephone signal method is particularly useful where operators, supervisors or load dispatchers must obtain measurements at remote locations periodically or during critical periods and where continuous indication or recording is not warranted. In this method, a telephone is automatically answered at the sending end whenever its number is called, and

* Made by General Electric Co., Schenectady, N.Y.

† Made by Westinghouse Electric Co., Pittsburgh, Pa.

‡ Made by Electric Indicator Co., Stamford, Conn.

§ Trade name of Builders-Providence, Inc., Providence, R.I.

‖ Trade name of Bristol Co., Waterbury, Conn.

a time signal is sent, the duration of which is a measure of the pressure, depth of water or whatever function is desired. The person obtaining the information may be at any telephone of an integrated system which, for the Bell System, might mean anywhere in the world. The person receiving the measurement must have a watch to time the signal and must know the factor to convert seconds into depth, pressure and so forth. The telephone at the sending end can be used for conversation, but it is not available for transmitting measurements during these periods.

This method is advantageous because it does not require a leased pair of wires as does the time impulse method. However, it cannot be used for continuous automatic control but only as a means of improving the quality of manual control.

Supervisory control. Supervisory control is a name given to a means of performing numerous operations and determining measurements over a pair of wires or over a carrier current channel using power transmission wires. The system uses coded impulses to perform many functions. It uses complex relay systems but has excellent reliability because the design of each component is simple.

The interconnecting circuit can be a twisted pair of communication type wires in a lead sheath installed to avoid close proximity to power lines. A telephone channel leased from the telephone company can be used. Open wires can be used if properly transposed and not subject to electromagnetic induction from power circuits which impose dangerous potentials on the control wires.

A carrier current channel may be the interconnecting circuit. Such a circuit requires only terminal installations and does not interfere with the function of the power lines. It is generally economically justified if the distance is greater than 10 miles. It obviously is only applicable where a power line interconnects the control and controlled points. It is used extensively by power companies, but its usefulness in water works is naturally limited. This method of transmission is exceptionally reliable and maintenance is limited to the terminal facilities.

Microwave radio interconnection is also practical for use in supervisory control.

When supervisory control is employed, any number of motors, breakers, valves or other units can be operated from a remote station and the positions of these units can be indicated at the control station. Also the readings of instruments can be obtained at the control station at any time the operator desires. If a unit at the remote station changes position, this change is relayed to the control station.

Miscellaneous electrical means of transmission. Other useful electrical means of transmission are:

1. The torque balance system, operating over a pair of wires and suited to distances up to 100 miles.
2. The inductance bridge principle, using three wires. This method is limited by the distance of transmission, the maximum practical distance being on the order of 1 mile.
3. The variable frequency method, which can operate over a pair of wires such as are available in telephone systems. It uses the entire frequency range and hence the same pair cannot be used for other purposes.
4. The high-rate impulse method, which can use telephone pairs.

Complexity of Automatic Control

Automatic devices range from the simple to the complex. A pressure-reducing valve and a bimetallic-strip-operated thermostat are simple automatic devices. Starting controls for synchronous motors and the controls for proportional chemical feed may be relatively complex. Simplicity or complexity is not in itself a measure of reliability or troublesomeness. Reliability is entirely a function of design, application and maintenance.

Water works people are apt to consider steam- or diesel-driven pumping stations as the ultimate in reliability, yet such stations and their components are exceedingly complex and include many automatic devices. Many of the components are subject to severe duty and loads when compared to the requirements of the components of an automatic control system.

In a steam plant, the necessary components may include all or most of the following: coal- and ash-handling equipment, coal crushers, stokers, boilers, draft fans, draft regulators, economizers, steam piping and valves, steam turbines, lubrication systems, governors, gear reducers, water-pumping units, condensers, feedwater pumps and feedwater treating systems. Most of this equipment is subjected to heavy loads and, because of cost considerations, must be designed with reasonable safety factors. All components are necessary to the functioning of the whole unit.

In a diesel plant, the necessary components may include all or most of the following: fuel-handling and supply system, injection units, governor, scavenging system, blower, crankshaft and bearings, pistons and rings, connecting rods, cylinder block and water jacket, exhaust piping and silencer, heat recovery unit, circulating water pumps, heat exchanger, cooling-water treating facilities; lubricating-oil pressure lines, pumps, filter and purifier, and cooler; gear-increasing units and water pumps. Similarly, the proper functioning of all of these units is essential to the operation of the station. Also, these components are subjected to severe operating conditions of load and temperature and, because of cost and mechanical limitations, cannot be overdesigned.

The reliability of both of these types of plants has been established only through good design, safe loading and proper maintenance.

To the designer, a system of automatic controls offers a much greater opportunity for securing reliability than do either of the above types of plants. Particularly in electrical equipment used for automatic control is there opportunity to employ large safety factors. In practically all automatic equipment—whether mechanically, pneumatically, hydraulically or electrically linked—there is little need for stressing materials to the limit required in equipment where weight and mass are costly and introduce mechanical problems—prime movers, for example. Most automatic control equipment is not subjected to severe wear or continuous mechanical motion. To illustrate this point, electrical relays, pressure-measuring diaphragms, springs and other components of automatic controls may be cited.

When the design of a control system is adequate, reliability is primarily dependent on understanding and maintenance. Understanding implies the ability to trace and correct trouble if it does occur. A person with such understanding should be readily available to the water department, although, in

small systems, he need not necessarily be a full-time employee.

If the design is good, proper maintenance resolves itself into the simple operations of inspection, calibration and cleaning. In the best designs, inspection should be all that is required. A proper design should include devices to indicate when automatic control has failed and simple means for converting to manual control until repairs have been made.

Advantages of Automatic Control

A list of advantages of automatic control should include: [1] Improvement of quality of product and service; [2] improvement in quality of personnel; [3] improvement in reliability (dependent on design and maintenance); [4] reduced costs.

1. *Improvement of quality of product and service:* As pointed out before, manual effort often cannot duplicate the performance of automatic control. In these instances it is obvious that the quality of product and service is improved. No one considers substituting manual effort for the services performed by the continuous chemical feeder, the rate controller, a stoker or a level controller. The inanimate materials of a properly designed control do not become fatigued and are continuously alert.

2. *Improvement in quality of personnel.* The human machine has serious faults which properly designed inanimate machines do not have. Aside from the fact that it does not have the stamina for continuously repeated operations as are sometimes required in automatic control, the human machine cannot always be trusted. This factor operates as an inverse function. The more menial the task, the more unlikely that the individual employed will be capable of assuming responsibility. There is no remedy for this situation. A higher rate of pay is only a temporary palliative. The best human machines will deteriorate in a monotonous and uninspiring environment.

By installing automatic control wherever feasible and practical, it will be possible to employ capable and trustworthy employes in interesting and challenging jobs for supervision and maintenance. The elimination of menial and distasteful tasks by installing automatic and labor-saving devices should release sufficient funds to merit employing intelligent and dependable operators at rates which will attract qualified persons. Such a program might have as its objective the centralizing of control of the purification plant in the laboratory, with instrumentation and controls so located that laboratory technicians could operate the plant. In a supply where chemical requirements vary, such an arrangement would make savings in chemical cost possible if laboratory control tests, to determine proper treatment, were carried on at regular intervals.

3. *Improvement in reliability.* Improvement in reliability can only be attained if the design and maintenance of the automatic control system is good. In general, it may be safely stated that the metals and characteristics of control devices can be made more dependable than human beings, but, of course, much depends on design.

4. *Reduced costs.* In general, the adoption of automatic control devices will bring about reduced costs. In an analysis to determine whether an item of automatic control should be installed, all costs, including capital and operating expense, should be evaluated, as well as the effect on the quality of the water or service. The effect on the

public welfare must always be taken into account.

Limitations of Automatic Control

Automatic control should not be employed: [1] where technology does not permit satisfactory control; [2] where reliable design is not possible; [3] where adequate maintenance cannot be obtained; and [4] where no advantage can be shown.

1. *Where technology does not permit satisfactory control.* Because of the extreme importance of a public water supply, high standards must be established as to what constitutes a satisfactory control. Ability to do the job must be proved. This ability should be evidenced in similar applications in other fields or should be capable of easy demonstration by study of the design or by short-time tests.

Examples of types of installations in which the present technology is not adequate or proved might include the control of chemical feeders by variations in effluent turbidity, the complete automatic control of a steam pumping plant (and, to a lesser extent, also of a Diesel pumping plant).

2. *Where reliable design is not possible.* In many systems, some element in the control scheme cannot be made reliable up to the standard required for water works operations. If remote control is used, the element may be the connecting link. In a system where gravity storage does not exist, the remote control of pumping operations using telephone circuits or private wires on poles may not be sufficiently reliable, but underground telephone circuits are usually sufficiently dependable. Sometimes there may be too much lag or inertia between the measuring and control points. This is often true in the control of purification processing where chemical reactions require long periods of time, although effective control has been accomplished by using several controlling devices in the process—for example, regulating the applied chemical both by chemical measurement and by flow measurement.

The physical design of the existing plant may make uneconomical or impractical the use of automatic control. For example, gravity flow of chemicals is preferable where automatic control is used. If the plant is designed for chemicals to be pumped, automatic, unattended operation of the chemical feeders may not be desirable.

3. *Where adequate maintenance cannot be obtained.* Maintenance personnel qualified to service automatic control equipment are not generally employed by water departments in communities of less than 10,000 population, which might be taken as an indication that automatic control should not be used in small supplies. Actually these supplies need automatic control the most because of the high cost of attendance per unit of output.

When automatic control is proposed by engineers, emphasis should be placed on the need for adequate maintenance. Generally, more highly qualified persons must be employed in the supervisory jobs. In fact, the maintenance of the water system is so vital to the continuity of service and to reliability that highly qualified supervision is necessary even where automatic control is not employed. If the design of the control system is good and if reasonably intelligent maintenance supervision is provided, automatic controls in small-town supplies can be justified. Periodic factory inspection and servicing should be arranged for under these conditions.

4. *Where no advantage can be shown.* There is a tendency (where no economic checks exist) for controls to be oversold. They are also overbought, because some people seem to associate lots of gadgets with good design. Simplicity should always be the keynote. If the objectives are achieved without extensive controls, then they should not be installed.

In lieu of automatic controls, the best device that can be installed to achieve proper manual control is a recording instrument. These are generally much less costly than automatic controls and, even when no saving in personnel can be made, will often achieve a satisfactory result. Human nature is such that the average employee will do his job well if he knows that otherwise the chart will tell on him.

Semiautomatic Controls

The question often arises whether water works processes are suited to fully automatic, unattended control. Qualifications naturally must be made before the question can be answered. If "fully automatic" means no attendance whatever, there are few water plants where such control is possible. Most water works equipment requires maintenance and inspection. If purification chemicals are required, deliveries must be made and storage hoppers must be filled. Periodic tests of water quality are usually needed. For discussion purposes, in the water works field, fully automatic control implies that inspection and servicing of the plant are necessary at regular intervals. Certainly any water system where public health is involved deserves daily inspection.

If the plant processes are simple, such as in iron removal installations, and if the raw-water quality is constant, fully automatic control is practical, provided storage is available for the interval required to dispatch someone to the plant when a failure occurs. The control system of such a plant should include an alarm and indication of proper operation at a location where someone is continuously available. In a small town, this could be at the fire department station or at the telephone exchange.

To safeguard the supply properly from the public health standpoint, interlocks should be provided which will shut down the entire plant or place in service standby units if any component should fail. When such safeguards exist, it is imperative that supervisory personnel be immediately notified if trouble occurs. Storage of treated water is essential in such a system.

In a small town where a carefully designed, interlocked, fully automatic system is used with simple provisions to convert to manual operation, dependability and quality should be better than in a manually operated plant. The operating jobs in a manually operated plant in a small town can seldom justify the rates of pay necessary to obtain employees with the dependability qualifications for the work, nor would a qualified person remain dependable in such a monotonous environment.

The field for semiautomatic control is less controversial and offers greater opportunity for saving and improvement of quality and personnel. In this category fall those devices and methods which utilize to the highest degree the automatic operation of units of a system, but centralize control so that highly trained and dependable personnel can operate the system. In such a plant, recording would be used to a

maximum, and this would provide a check on the performance of the centralized control.

Semiautomatic control can be used in the operation of an integrated distribution system with several outlying storage basins, control valves and pumping stations in use. A centralized control could be set up through which all information would clear and be used for determining the mode of supplying the demand.

Semiautomatic control can be used for all units of centrally operated plants wherever possible to eliminate the menial and demoralizing tasks of attending motors and other mechanical equipment. Automatic safeguards against the effect of bearing failures, motor overloading, overflow of solution pots, starvation of chemical feeders and failure of pumps are available which are infinitely more effective and dependable than human beings.

Purchased Power

Admittedly the self-contained steam or diesel power plant is not so suited to automatic control as is the plant using purchased power. Many automatic devices are desirable and necessary in the self-contained power plant. However, if such power plants are used in a water system, it is unlikely that they will ever be made fully automatic to the extent they can be operated from a remote location.

Because of the size limitation of the average water plant, its power load does not lend itself to the economy of power production that is possible in centralized electric utility power plants. In spite of rising costs, power utility rates have remained low, primarily because most large, integrated utility systems have a higher average standard of economy in relation to current technological progress in the field than is possible in a single power plant. If a water works installs a power plant, it is committed to one standard of economy for at least 30 years. The size limitation and the magnitude of the problems preclude the use, in the average water plant, of the highest steam pressures and temperatures and the turbine sizes which now make possible the lowest cost of power production.

Thus there is a trend toward the electrification of water works using purchased power. Electric power is most suited to the use of automatic control. With proper design, there is little excuse for electric pumping facilities to be attended. Safeguards against possible failures or sources of trouble are available for remotely controlled installations. The cost per unit is so low relatively that additional standby units can be justified when there is a question regarding reliability.

Summary

It can be safely stated that the present advances in the art of automatic control merit considering the automatic operation of many water works processes which are not now generally automatic. In using automatic control, careful and rugged design is necessary and intelligent maintenance supervision should be available. Automatic control makes possible the employment of better trained personnel because of the savings that can be made. Every automatic control design should include an automatic-manual switch making it possible to change over to manual control easily and surely. Automatic control should not be installed if no advantage can be shown. Recording instruments are good insurance for proper operation when manual control is employed.

Disposal of Softening Plant Wastes

Committee Report

A report, presented on June 2, 1949, at the Annual Conference, Chicago, by two members of Committee W-8—Disposal of Wastes From Water Purification and Softening Plants. The report consists of two papers—by A. P. Black, Head, Dept. of Chemistry, University of Florida, Gainesville, Fla., and Paul D. Haney, San. Engr., Environmental Health Center, U.S. Public Health Service, Cincinnati, Ohio—dealing with the softening waste aspects of the committee's work.

Lime and Lime-Soda Sludge Disposal—*A. P. Black*

IN the progress report of the committee presented at the San Francisco Conference in 1947 (1), it was pointed out that the disposal of the sludge produced by lime or lime-soda softening plants is rapidly assuming greater importance for three reasons. In the first place, this country is rapidly becoming "soft-water conscious" and more and more people are demanding soft water for domestic and industrial use. The data presented in Table 1 bring this fact out very clearly. The table compares the findings of a census of United States municipal water softening plants made by Olson (2) in 1941 with the findings of a similar census made by the same author in 1944 (3). The table shows that, in spite of wartime controls, a total of 89 new softening plants were built in this country during the four-year period, of which 50 were lime or lime-soda plants and 39 were zeolite plants. The table indicates that the ratio of chemical precipitation plants to zeolite plants was not significantly changed by the new construction.

The 1944 census shows that only nine states—Connecticut, Idaho, Maine, New Hampshire, Oregon, Rhode Island, Utah, Vermont and Wyoming—have no softening plants. It is further shown that the great majority of the 89 plants constructed during the four-year period were small. Specifically, 47 were built in cities of less than 1,000 population, 32 in cities with a population between 1,000 and 5,000, 9 in cities with a population of 5,000 to 10,000 and only 2 in cities above 10,000. Olson estimates that at the beginning of 1945, 11,804,230 people were served soft water from municipal softening plants. In his 1945 census, he presents additional data covering the population served by domestic softeners and by soft water service systems (4).

The second reason for the growing importance of softening sludge disposal is that this country has become "pollution conscious" and many states have enacted laws which prohibit dumping such materials into streams or watercourses. This matter will be more fully discussed below. The third reason is that the general increase in the population of urban regions has limited the amount of land available in such areas

for the disposal of softening sludges by ponding or lagooning. This point is obvious and requires no further discussion.

Character of Sludge

Chemical composition. The sludge produced in softening water by the lime or lime-soda process consists principally of calcium carbonate with varying amounts of ferric, magnesium and aluminum hydroxides. The amount of magnesium hydroxide will vary with the magnesium content of the water and the amount of ferric and aluminum hydroxides will vary with the type and amount of coagulant used. Table 2 presents the results of the chemical analysis of three different water-softening sludges. The first is that resulting from softening the water at Boulder City, Nev. by excess lime-soda treatment. The raw water contains 25 ppm. of magnesium and this analysis might be considered as fairly typical of sludges of that character (5). The second sludge is that produced by softening the low-magnesium municipal supply of Miami, Fla. The magnesium content of the raw water is only 6.9 ppm., and as shown by the analysis of the sludge, very little of it is removed in softening. The third is the sludge resulting from selective lime softening of the water at the plant of the Wright Aeronautical Corp. (6). That selective softening may be successfully practiced is shown by the fact that the magnesium oxide content of the Wright Corp. sludge is only slightly higher than that of the Miami sludge.

TABLE 1

U. S. Municipal Softening Plants

Type	1941	1944
Chemical precipitation		
Number	377	427
Per cent	65.5	64.2
Zeolite		
Number	199	238
Per cent	34.5	35.8
Total plants	576	665

Particle size. Studies indicate that the average particle size of dried sludge is very small. Sheen and Lammers (6) state that the sludge produced by selective lime softening at the Wright Aeronautical Corp. has an average particle size of 5–7 μ. Pedersen (7) reports that an accurate analysis of the dried sludge at Marshalltown, Iowa, by the Oden sedimentation method disclosed that 99.8 per cent passed a 325-mesh screen while 20 per cent passed a 3,000-mesh screen. Screen analysis of the dried product indicated that over 96 per cent passed through a 325-mesh screen. From Table 3 it can be seen that the particle size of the sludge from the Miami softening plant is of the same order of magnitude.

TABLE 2

Chemical Composition of Dry Sludges

Constituent	Per Cent by Weight *A**	*B*†	*C*‡
Silica and insoluble	2.6	0.67	0.0
Iron (Fe_2O_3)		0.78	2.7
Aluminum (Al_2O_3)			1.7
Calcium oxide (CaO)	48.8	52.1	49.3
Magnesium oxide (MgO)	7.0	1.8	2.2
Loss on ignition		43.8	
Carbon dioxide (CO_2)	38.4		40.2
Equivalent $CaCO_3$	87.2	93.0	88.1

* Boulder City, Nev.
† Miami, Fla.
‡ Wright Aeronautical Corp.

Quantity of Sludge Produced

Theoretical yield, dry basis. The addition of 1 lb. of pure calcium oxide will theoretically produce 3.57 lb. of dry calcium carbonate sludge if it is

assumed that only calcium hardness is removed. In like manner, the addition of 1 lb. of pure calcium hydroxide would produce 2.7 lb. of dry calcium carbonate sludge. In practice, the amount of sludge obtained per pound of commercial quicklime or hydrated lime is substantially less than these figures, because neither form of lime is pure and variable amounts of magnesium are usually removed at the same time. Nelson (8) assumes an average yield of 2.5 lb. of sludge, dry basis, for each pound of commercial quicklime added. Swab (9) assumes the same

TABLE 3

Sludge Particle Size

Size μ	Cumulative Weight *per cent*
24	99
21.2	97
17.5	92
14	82
11.5	72
9.2	59
6.2	38
4.9	30
3.4	20
2	12
1.3	5

figure in calculating the total amount of dry calcium carbonate sludge to be obtained at Pontiac, Mich.

Physical character. The total volume of wet sludge produced in a softening plant will depend both upon the physical character of the solid material and the percentage of solid material in the wet sludge. It is in this respect that the sludges from lime and lime-soda softening plants vary most widely. Nelson (8) is one of the few authors to point out the fact that the characteristics of sludge at various water softening plants differ radically. He states that, while some sludges will concentrate in the sedimentation basins to 27–33 per cent solids, for others it is difficult to obtain 10 per cent solids. Furthermore, he points out that it is questionable whether the percentage of solids in the sludge obtained from any given water can be predicted with any degree of accuracy. This statement is borne out by the highly variable figures given in the literature for the per-

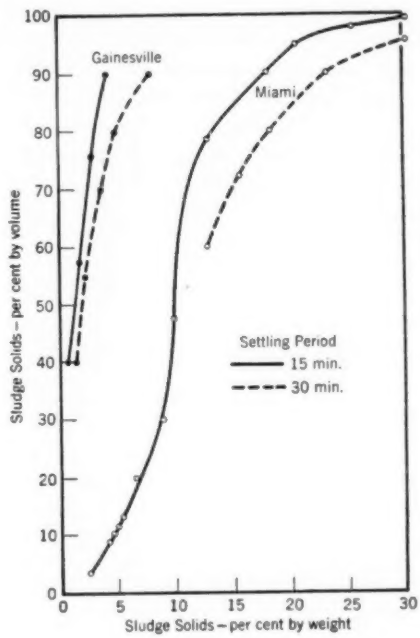


FIG. 1. Comparison of Two Sludges

centage of solids in softening sludge. Sowden (10) reports that the sludge obtained in pilot plant studies using Minneapolis water contained 2–5 per cent solids. In his paper, he outlines a simple, rapid and accurate method of determining the percentage of solids present in water softening sludge and presents an equation by which the percentage of solids can be calculated from

readily obtainable data. Swab (9) reports that slurry from the settling tanks of the new Pontiac plant are expected to contain approximately 15 per cent solids. Sheen and Lammers (6) state that the sludge discharge from the softeners at the plant of the Wright Aeronautical Corp. contained approximately 5 per cent solids. One manufacturer, in estimating the percentage of solids in the sludge to be obtained in softening water from a new well field in Miami, Fla., uses a figure of 10 per cent, whereas another manufacturer uses a figure of 15 per cent for the same sludge. Weed (11), checking the sludge produced in the softening plant of the Socony Vacuum Oil Co. at East St. Louis, Ill., found 10.2 per cent at the beginning of the sludge blowoff, 9.0 per cent at the middle of the blowoff period and 8.5 per cent at the end of the period.

Volume of sludge produced. Even more important than the percentage by weight of solids is the volume which they occupy in the wet sludge, and it is in this respect that softening sludges exhibit their greatest variation. Two sludges tested by the author exemplify the very wide variations which may be encountered. The percentage of solids by volume was determined by allowing 100-ml. samples of the wet sludge to settle in 100-ml. graduated cylinders for specified periods of time. The percentage by weight was determined by filtering and weighing the dried sludge. The results are illustrated in Fig. 1. It will be noted, for example, that for the crystalline calcium carbonate sludge at Miami whose analysis is shown in Table 2, 30 per cent solids by volume after fifteen minutes' settling was equivalent to 8 per cent solids by weight; and 90 per cent solids by volume after 30 minutes' settling was equivalent to 23.5 per cent solids by weight. However, very different values are obtained for the bulky, flocculent sludge at Gainesville, Fla., where the water contains 15 ppm. of magnesium and 17 ppm. of alum is used as coagulant. For this sludge, 40 per cent by volume after fifteen minutes' settling was equivalent to only 0.5 per cent solids by weight, and 90 per cent by volume after 30 minutes' settling was equivalent to only 7.6 per cent solids by weight.

It is readily apparent, therefore, that the amount of water pumped to waste in discharging a dense, crystalline sludge similar to that at Miami will be far less than the amount pumped to waste in discharging bulky, flocculent sludge similar to that produced at Gainesville. This observation, likewise, is borne out by statements in the literature. Weed (11), in his tests of the sludge at the Socony Vacuum Oil Co. plant at East St. Louis, found that the total volume of water and sludge blown off was 0.8 per cent of the water softened. Sowden (10), in his pilot plant work at Minneapolis, found that the volume of sludge produced there varied between 1.5 per cent and 6 per cent of the volume of water softened. At Gainesville, the volume of sludge discharged varies from 3 to 5 per cent of the volume of water softened. Calculations indicate that the volume of water required to discharge the dense, crystalline sludge to be produced in the new plant at Miami will not exceed 0.3–0.5 per cent of the volume of water softened.

Effects on Environment

Since softening sludges are composed for the most part of inorganic matter, they would not ordinarily be expected to produce odors, although they might

do so in waters containing considerable organic matter. Even then, however, the high pH of the sludge might be expected to insure reasonable stability. There is little information available on the biochemical oxygen demand of such sludge and the consequent reduction in the dissolved oxygen content of water into which it might be discharged. Certainly, the discharge of such sludge into a flowing stream might be expected to neutralize at least a part of the free carbon dioxide and to increase the pH value of the water, the magnitude of both of these effects depending, of course, upon the amount of sludge discharged in relation to the flow of the stream. By and large, however, the most important effect to be expected in the discharge of softening sludges into streams is a considerable increase in turbidity and the formation of sludge banks when the velocity of flow is low.

Legal and Administrative Aspects

During the course of these studies, the chairman of the committee circularized all the state sanitary engineers, requesting information on regulations governing the disposal of wastes from water treatment plants. To the question "Is the discharge of water-softening sludge without treatment considered a violation of your water pollution laws?" 28 replies were received. They may be summarized as follows:

Group I—Unqualified "No": 12
Group II—Qualified "No": 4
Group III—Unqualified "Yes": 10
Group IV—Qualified "Yes": 2

In Group I are included Alaska, Colorado, Delaware, Kansas, Louisiana, Maine, Nevada, South Dakota, Utah, West Virginia, Wisconsin and Wyoming; in Group II, Georgia, Kentucky, New Hampshire and North Carolina; in Group III, Arizona, California, Illinois, Iowa, Massachusetts, Michigan, New Jersey, North Dakota, Oklahoma and Pennsylvania; and in Group IV, Missouri and Tennessee. Keeping in mind the fact that 9 states have no softening plants, it is evident that of the remaining 39, only about one-third have to date enacted legislation relative to the disposal of such sludges.

Disposal Methods

In order to secure reasonably accurate data on the disposal of softening sludges, a questionnaire was mailed to the state sanitary engineers of 21 states. The states selected were those shown by Olson's 1944 census (3) as having in general the largest number of softening plants. Replies were received from all states and information was obtained covering 371 lime or lime-soda softening plants. The 1944 census showed a total of 427 lime-soda softening plants, of which 395 were in the 21 states used for the study. The 371 plants from which information was received represent, therefore, 87 per cent of all the lime-soda softening plants in the country in 1944 and 93.9 per cent of the plants in the 21 states used for the study. It is believed, therefore, that this coverage is amply complete to give a true picture of the present situation.

It will be noted, from the data presented in Table 4, that 217, or 58.4 per cent of all plants studied, dispose of the sludge in flowing watercourses and 110, or 29.6 per cent of all plants studied, employ sludge beds or lagoons. This means that 327 of the 371 plants studied, or 88 per cent, employ one or the other of these two methods. Thirty-

three plants, or 8.6 per cent of those studied, add the sludge to a storm or sanitary sewer. Of these, 13 discharge the sludge into sanitary sewers, final point of disposal unknown; 9, into storm sewers; and 13, directly into some type of sewage treatment plant. without odor or fly nuisance. On the other hand, at Shelby, Ohio, where the softening sludge was formerly discharged to the sewage treatment plant, it is now lagooned separately. At Chillicothe, Ohio, however, where lagooning was first practiced, the sludge is

TABLE 4

Sludge Disposal Methods in 21 States

State	Number of Plants Reported	Sludge Disposal Method*				
		A	*B*	*C*	*D*	*E*
Arkansas	3		2		1	
California	8	3			5	
Florida	31	16	5	6	3	2
Georgia	5		5			
Illinois	41	27	5		7	2
Indiana	6	3	3			
Iowa	20	7	6	1	5	1
Kansas	26	4	21		1	
Louisiana	17	2	12		3	
Michigan	13	8	4	1		
Missouri	19	2	17			
Montana	3		2		1	
Nebraska	3		2		1	
North Carolina	2		2			
North Dakota	11	2	8		1	
Ohio	109	31	76		4	
Pennsylvania	23	2	21			
South Dakota	8		7		1	
Texas	8		8			
West Virginia	5		5			
Wisconsin	10	3	6			1
Total	371	110	217	8	33	6
Percentage	100	29.6	58.4	2.1	8.6	1.6

* Key to symbols:
A—Disposal in sludge beds or lagoons
B—Added to flowing watercourse
C—Added to body of water other than *B*
D—Storm or sanitary sewer, point of discharge not always indicated
E—Other methods.

A number of interesting observations were received. For example, at Lebanon, Ind., the softening sludge was found to stop digestion and to plug the digestion tanks, so that primary sewage sludge and lime softening sludge are now lagooned together. The result is said to be a relatively stable sludge now discharged through city sewers into the sewage treatment plant. Disposal in a watercourse has been abandoned at Greensburg, Ind., and Marshalltown, Iowa. In the former, it was abandoned because of lawsuits and sand beds are now used. In the latter, lagooning is now employed. At Coro-

nado, Calif., a lagooned sludge is employed for trench backfill to protect against the external corrosion of water mains. At Perry, Iowa, the sludge is filtered on vacuum filters and hauled away by farmers. At Hilbert, Wis., the wet sludge is hauled by tank wagons to nearby farms.

An examination of Table 4 indicates that in Kansas, Louisiana, Missouri and Pennsylvania disposal in flowing watercourses is the usual method. This is also true, although to a somewhat lesser extent, of Ohio, whereas Illinois leads all the states in the use of sludge beds or lagoons, closely followed by Florida. In connection with the disposal of sludge in beds or lagoons, Hoover (12) estimates that 0.00211 acre-ft. of lagoon storage space is required for each million gallons of water softened. Nelson (8) estimates that, when using a dosage of 240 ppm. of lime and assuming a sludge containing 15 per cent solids, there would be required 2 acre-ft. of lagoon a year for each million gallons of water treated. Dittoe (13) points out the difficulties encountered in disposing of sludge in lagoons.

Two relatively new and interesting methods of sludge disposal are worthy of special comment. The first of these is its employment as a chemical coagulant in a new sewage treatment plant at Daytona Beach, Fla., which has been described by Williamson (14). The plant consists of two "suspended solids contact" basins in which primary treatment of the sewage is effected by precipitating it with sludge from the municipal water softening plant. Provision is made for feeding additional lime and chemical coagulants, if required. The new plant has not yet been placed in full operation, and it is therefore impossible to present at this time actual operating data. Pilot plant experiments indicated an overall B.O.D. removal of 70 to 80 per cent with only one-hour detention in the specially designed suspended solids contact basins. If these results are borne out in actual practice, the B.O.D. reduction will be approximately twice that of conventional primary treatment plants. Yet the first cost will be much less than that of a plant for primary treatment as ordinarily provided.

The second novel disposal method consists of dewatering the sludge, followed by either drying to produce calcium carbonate or calcining to recover quicklime for reuse in the softening process. Theoretically, every pound of of lime added to water containing carbonate hardness produces 3.57 lb. of sludge, which can be dried and calcined to produce 2 lb. of lime. In actual practice, 100 per cent recovery is not obtained, but more lime can usually be produced than is required for the softening process.

According to Hoover (15), in 1938 there were five principal reasons why this reclamation of lime from softening plant sludge had not been adopted in the United States: [1] most of the larger plants have been built adjacent to sizable waterways into which the sludge can be dumped; [2] most of the larger plants soften and purify river water supplies, and the ever changing water and resultant variation in sludge quality makes the reburning of sludge quite complicated; [3] the prevention of the accumulation of magnesium in the reclaimed lime was accomplished only recently; [4] satisfactory calcining equipment, particularly to handle small quantities of material, was not available; and [5] small communities

usually take their water supply from wells, and, although the water is clear and lends itself to a reburning scheme, these communities generally did not wish to embark upon a new procedure of this kind which had not been tried elsewhere.

Conditions have changed somewhat during the past nine years. As more stringent stream pollution measures are enacted, even plants situated on large streams may be enjoined from continuing the pollution of the stream with relatively insoluble sludge. Although the variations in quality of a raw-water supply cannot be controlled, several cities are endeavoring to obtain sufficient reservoir capacity ahead of the plant to smooth out the peaks in the quality fluctuations at least partially. Lime reclamation units could be employed at some of the plants located on a fluctuating supply by operating the equipment only when the water is relatively clear, storing the excess lime produced during this period for use when the water is turbid. The prevention of the buildup of the undesirable magnesium in reclaimed lime has been accomplished by two methods: [1] a split treatment in which the magnesium is generally precipitated separately from the calcium as is done in the Lykken-Esterbrook or the Hoover processes (15); or [2] the physical separation of the magnesium hydroxide from the calcium carbonate during the dewatering of the sludge in a centrifuge (8).

Calcination of Sludge

The rotary kiln has long been used satisfactorily to calcine materials comparable to those produced during the softening process (8, 16), but the efficiency of operation of such a unit is generally proportional to the amount of material being handled. Also, such a kiln for the small water-softening plant would be a major piece of equipment involving as much or more operating supervision than the water plant itself, and the thermal efficiency of the small rotary kiln required would not be good. Consequently, the adoption of lime reclamation processes has been deterred. Multiple-hearth furnaces have been used for this purpose, but investigations subsequent to those reported have indicated that such furnaces, operating at the high temperatures required for lime calcining, have required an unusual amount of maintenance to keep them functioning properly. Developments in the last few years may have improved their operation.

Two calcining furnaces which appear to hold considerable promise for the small plant operator have been developed and are now being tested. Both are stationary, vertical units which can be made to handle a small or large quantity of material. Both systems have recently been described by Fisher and Gordon in their discussions of Swab's paper on the proposed Pontiac recalcining plant (9). One was developed by H. V. Pedersen, Supt., Water Dept., Marshalltown, Iowa, in conjunction with the Raymond Pulverizer Div. of the Combustion Engineering Co., Chicago. After six years of experimental work, Pedersen is ready to go ahead with the construction of a permanent lime reclamation plant embodying the flash calcining furnace. It is planned to construct a drying and calcining plant having a capacity of 10 tons per 24 hours, to operate in conjunction with the 4-mgd. softening plant. The calcining plant is to be operated only eight hours per day, because Pedersen's studies indicate that

it will cost less to operate a 10-ton plant for eight hours than to operate a smaller one for a longer period of time (7, 9).

The Dorr Co., New York City, has in successful operation several full-size units utilizing the "FluoSolids" principle on materials other than softening plant sludge. The company has completed extensive laboratory investigations on the calcination of softening sludges which indicate the feasibility of this process for lime reclamation. A FluoSolids pilot plant is now in operation at Lansing, Mich., having a capacity of 6 tons per 24 hours. It is to be operated in conjunction with the 20-mgd. softening plant of that city. This furnace produces a very unusual pelletized, almost dust-free product (9).

TABLE 5

Available CaO in Recovered Lime

Date (1949)	Available Lime (CaO) *per cent*
May 6	92.0
	92.4
	87.3
May 7	93.2
	No Sample
	92.4
May 8	92.9
	92.2
	No Sample
May 9	92.5
	92.7
	88.4
May 10	93.1
	93.0
	92.3
May 11	94.6
	93.7
	90.3
May 12	93.4
	92.6
	92.4
May 13	93.1
	93.1
	93.9
Avg.	92.3

The Metropolitan Water Dist. of Southern California has continued its investigations on lime reclamation in connection with the 200-mgd. softening plant at LaVerne, Calif.

Miami Lime Recovery Plant

The new lime recovery plant of Miami, Fla., was inaugurated early in 1949, and, after a shutdown of several days' duration for necessary adjustments, was placed in continuous operation on a 24-hour basis. It is a rotary kiln, 7 ft. 7⅝ in. in external diameter and 230 ft. long, and has a rated capacity of 80 tons of quicklime per day. By May 15, 1949, it had produced in 58 working days a total of 2,877 tons of quicklime. The average operating rate during the period was 49.3 tons per day. Most of the material was used in the Miami water softening plant, but 130 tons were shipped during that period to Tampa and Gainesville, Fla. Analysis of the first car shipped from the new plant showed a silica (SiO_2) content of 0.5 per cent; iron and aluminum oxides (R_2O_3), 1.2 per cent; magnesium oxide, (MgO), 1.3 per cent; and available lime (CaO) (A.S.T.M. C25–47), 90.1 per cent.

Greater familiarity with the use of the kiln has resulted in a steadily improved product, as shown by the series of analyses over an eight-day period presented in Table 5. As it drops from the kiln, the lime is in the form of nodules almost spherical in shape and varying from the size of a coffee bean

to $\frac{3}{4}$ in. in diameter. The product is slightly underburned to facilitate slaking, and because of that fact the nodules are quite soft and have a tendency to powder, both in handling in the plant and in shipping. The density of the material is unusually low, the weight being only about 35 lb. per cubic foot. It is readily handled in pneumatic conveying equipment.

The temperature maintained in the slakers now varies between 170° and 173°F. In the lime formerly used, which was shipped from Tennessee, it was difficult to obtain a temperature in the slaker in excess of 140°F. because of air slaking during shipment.

It is not possible at this time to give accurate cost figures. The cost, however, will be considerably in excess of the figure of $6.02 estimated in 1945. Even though accurate figures are not as yet available, it is possible to state with certainty that the savings effected by Miami through the use of the new product will reach $100,000 annually within the next two years. The total cost of the plant will be in excess of $700,000.

Summary

What are the prospects for the future? In addition to [1] ponding or lagooning and [2] disposal in watercourses—these methods of disposal representing present practice in the great majority of plants—four other methods appear to offer attractive possibilities: [1] utilization as a precipitant in primary sewage treatment if the first plants using that process prove successful; [2] dewatering, drying and pulverizing, as carried out at the plant of the Wright Aeronautical Corp., and disposing of the dried product for a variety of industrial uses; [3] dewatering and calcining in small stationary kilns, of which two types have been described; and [4] for the larger installations, recalcining in rotary kilns.

The operating results of all four of the above processes will be watched with great interest by water softening plant operators and designing engineers.

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Brine Disposal From Cation-Exchange Softeners—*Paul D. Haney*

Wastes from sodium zeolite (cation-exchange) water softening plants consist of wash water containing the waste products of the regeneration cycle plus unused salt. These waste products are composed principally of the chlorides of calcium and magnesium, together with small amounts of various compounds of iron and manganese.

TABLE 6

Brine Sample Analysis

Item	*ppm.*
Silica (SiO_2)	12
Iron (Fe)	0
Calcium (Ca)	1,720
Magnesium (Mg)	600
Sodium & potassium (Na & K)	3,325
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	137
Sulfate (SO_4)	328
Chloride (Cl)	9,600
Total dissolved solids	15,654
Total hardness	7,762
Carbonate hardness	112
Noncarbonate hardness	7,650
Phenolphthalein alkalinity	0
Methyl orange alkalinity	112
Free CO_2	7
pH (at 17°C.)	7.5
Specific electrical conductance	$2{,}650 \times 10^{-5}$ mho

Quantity and Character of Wastes

Wash water requirements generally vary from about 3 to 10 per cent of the amount of water treated. The waste wash water will contain chloride ions (principally from sodium, calcium and magnesium compounds) proportional to the amount of salt used in regeneration—ranging from about 0.25 to 0.5 lb. of salt per 1,000 grains of hardness removed. The amount of chloride ion per million gallons of water softened which must be disposed of in the wash water may be approximated by the formula $C = 35SH$, in which C represents the chloride ion, expressed in pounds per million gallons; S is the salt, in pounds per thousand grains of hardness removed; and H is the reduction of hardness, in parts per million as calcium carbonate ($CaCO_3$).

An analysis of a composite sample of spent brine discharged from one large zeolite plant using upflow softeners is shown in Table 6. At this plant, it was found that the maximum concentrations of calcium, magnesium, sodium and potassium, chloride, total dissolved solids and hardness in the spent brine discharged were about six times the values obtained on the composite sample.

Effects of Wastes

Significant increases in chloride, sodium, calcium, magnesium and solids concentrations will be noted unless ample dilution water is available in the stream or other body of water receiving these wastes.

The U.S. Public Health Service (1) suggests that: "the following chemical substances which may be present in natural or treated waters should pref-

erably not occur in excess of the following concentrations. . . . Magnesium should not exceed 125 ppm. . . . Chloride should not exceed 250 ppm. . . . Total solids should not exceed 500 ppm. for a water of good chemical quality. However, if such water is not available, a total solids content of 1,000 ppm. may be permitted."

Solids of the type added to water by zeolite wastes cannot be removed entirely by ordinary water treatment methods. Calcium and magnesium can be reduced by a combination of lime and soda ash treatment, but the chloride will remain unaffected, and the total solids after such a treatment will be greater than before. Damage to a water supply by salt wastes from sodium zeolite plants or from any other source is irreparable, as far as any treatment method generally available for use by a public water supply is concerned.

If brine wastes are discharged into a sanitary sewer system, the question of their effect on the functioning of the sewage treatment plant and sewage pumping stations must be considered. Brine wastes may cause corrosion of pumping equipment and force mains and, if these wastes reach the sewage treatment plant in a "slug," they might cause a serious upset in the biological phases of the treatment, in addition to corroding plant equipment.

Fish may be killed if brine is released and travels downstream in a "slug." The limiting concentrations are not definite, however. Certain fish may be able to tolerate 5,000–10,000 ppm. of sodium chloride for short periods, but calcium and magnesium appear to be more toxic (2). Concentrations which will allow the maintenance of good, varied aquatic life are far lower than the values that fish can tolerate for short periods.

It is believed that a total salt content of approximately 1.5 per cent (15,000 ppm.) should be considered the upper limit for stock water (3). For lactating animals, the limit is lower, and much less highly mineralized water is, of course, preferable. The damage to animals appears to depend not so much on the kind as on the amount of salt present. Experiments with chickens, hogs, sheep and cattle have proved that waters containing high concentrations of such salts as sodium, calcium and magnesium chloride are injurious to these animals (3).

Brine wastes, unless quickly diluted, will destroy vegetation in and along the banks of receiving channels.

Operating Experiences

Few reports of actual operating problems involving the disposal of spent brine are available, and it may be inferred that to date brine disposal from zeolite plants has not usually presented a very serious problem. Some instances involving difficulties of one kind or another which have come to the author's attention are described below.

1. Some years ago the rinse water from a zeolite softening plant located in a small midwestern city was allowed to flow into an open drainage pit constructed in a clay formation. Apparently the idea was that the brine would percolate into the ground. The clay did not prove to be very permeable however, and the pit soon filled and overflowed into a nearby small stream. It is said that cows, pigs and chickens which drank from this stream were caused great distress and that some died. This difficulty was overcome by

diverting the overflow from the pit to another drainage channel.

2. At another midwestern city, a zeolite softener was installed near a small stream and the rinse water allowed to discharge to the stream. During a drought the stream dried up and the rinse water percolated through cracks in the stream bed and polluted the ground water. The pollution was noted in the water from nearby wells. This condition was remedied by piping the wastes away from the softening plant.

3. In one eastern state, the health department reported that brine wastes have caused difficulties in two localities. In one, the wastes were discharged into an open ditch with practically no dilution and then flowed for about 1,000 ft. before reaching a sizable stream. The vegetation was killed along this ditch for a distance of several feet from the water's edge on both sides, and property owners objected. The remedy was the construction of a brine drain. Another village discharged the waste brine from a softener into a pond near its wells rather than construct a suitable drain. This practice led eventually to the pollution of the well water supply. A drain was constructed to remedy this situation.

4. At a British city, several experiments were conducted in the disposal of waste zeolite softening brine: A pit was excavated 6 ft. into a chalk formation and into it was washed 12 tons of common salt over a period of 48 hours. The chloride content of the well from which the city's supply was obtained, and of other neighboring wells, was determined frequently, before, during and after the test. Within 48 hours of the discharge of the last of the salt, an appreciable increase in the chloride content of a nearby well was recorded, and within a week of the start of the test, it was evident that a diffusion of the brine had taken place in the chalk over an area roughly represented by a semicircle having a diameter of approximately 2 miles. Any idea of discharging the saline waste into an adjoining small watercourse had to be abandoned, and it was decided that the softening plant would have to be erected at a site which would permit the waste to be discharged into a public sewer (6).

5. The Metropolitan Water Dist. of Southern California investigated the problem of zeolite brine waste disposal prior to the construction of a zeolite softening plant. It was found that, because there were no continuously flowing streams in the vicinity of the proposed plant, and because of the geologic structure of the coastal plain, the brine could not be discharged into a stream or spread upon the land. Studies of solar evaporation indicated that it would not be an economically feasible method of handling these brines. It was necessary, therefore, to make provision to transport the brine to tidewater. The cost of a conduit for carrying the brine to tidewater was taken into consideration before deciding upon the zeolite method of softening. Fortunately, it was possible to conclude an agreement with the Los Angeles County sanitation districts to connect the zeolite plant waste water drain to the sanitation districts' sewer, so that it was unnecessary to carry the drain all the way to the ocean. As built, the water plant waste line is 22 miles long and has a capacity of 15 cfs. The line was built of precast concrete at a cost of $466,000. Had it been necessary to carry this line the remaining 28 miles

to the ocean, the cost would have been over $1,000,000. Until 1948 the water district paid a sewer service charge of $30.00 per million gallons of waste brine. Since the waste brine amounts to about 2 per cent of the total plant output, this charge represents a brine disposal cost of $00.60 per million gallons of water softened. Inasmuch as the sanitation districts' trunk sewer to which the waste brine line presently connects cannot carry the ultimate load from the water plant as well as the sewage load, it has been necessary to construct a larger trunk sewer, a portion of the cost of which will be borne by the water district. The water district will pay $100,000 cash plus an annual service charge of about $16,000 for 40 years. In addition, there is a service charge of $1.00 per million gallons of waste brine.

Results of Questionnaire

A questionnaire sent to all state health departments on water treatment plant waste disposal problems contained a series of questions about the disposal of wastes from zeolite softening plants. The results of this questionnaire are summarized in Table 7.

TABLE 7

Results of Questionnaire

Question No.	Question	States Replying		
		No.	*per cent*	
			"Yes"	"No"
1	Is the discharge of brine wastes from zeolite softeners customarily practiced in your state?	41	66	34
2	Are such wastes classed as pollutants?	32	69	31
3	Is their discharge without "treatment" considered a violation of your water pollution law?	29	62	38
4	Are you now requiring provision for "treatment" of these wastes in connection with plans for new purification plants?	29	48	52
5	Is there likelihood of requiring "treatment" of wastes from existing plants?	29	38	62
6	Are there state laws in force pertaining to the disposal of such wastes into streams or by other means?	41	54	46

Most of the answers to the various questions were qualified. Those health departments answering "No" to Question 1 indicated that there were no important zeolite plants and consequently no significant amounts of waste in their states. The principal qualifications in the answers to Questions 2–6 were those relating to demonstration of damages and considerations of stream uses.

Most of the states correctly interpreted the word "treatment" in Questions 3, 4 and 5 to mean "suitable means of disposal."

From the comments accompanying the questionnaires, it appears that most states do not consider the disposal of waste brine a serious problem at present but are prepared to take action if damage does result from existing or

future installations. A few expressed concern about the possibility of future difficulties.

In answer to an additional question regarding "treatment" methods (interpreted as "disposal" methods), six states suggested lagooning; two states, holding tanks with controlled discharge; three, discharge to sewer system; three, discharge direct to streams; two, injection (brine disposal) wells; and one, solar evaporation.

Disposal Methods

1. *Evaporation ponds.* Except under very unusual conditions, solar evaporation does not appear to offer a satisfactory means for the disposal of zeolite plant wastes. Studies (4) made in Kansas of the disposal of oil field brines have indicated that the evaporation of the brines may be less than —or, at best, may barely exceed—the rainfall. Evaporation data for fresh waters are not applicable to brines because of the lowering of the vapor pressure of the water by dissolved salts. Any evaporation which does occur serves to increase the concentration of the dissolved salts with further lowering of the vapor pressure and retardation of evaporation. This cycle continues up to the point of saturation. Even if evaporation is successful, there remains the problem of disposing of the residual salts.

If the soil is porous, a watertight pond may be quite expensive to construct. Brine seepage from a poorly built pond may result in the mineralization of nearby surface streams or ground water. Many ponds intended for the "evaporation" of oil field brines have actually proved to be seepage ponds. Practically all of the water loss from them has been due to seepage into the surface drainage or into a shallow aquifer.

2. *Uncontrolled dilution.* The discharge of the salt-bearing wash water into a stream, directly or by way of a city sewer system, offers a simple means of disposal, provided adequate dilution water is available. The amount of dilution water must be great enough at the time of the brine discharge to dilute the wastes so that water users and aquatic life downstream will not be damaged.

3. *Controlled dilution.* Disposal by controlled dilution requires short- or long-period storage of the brine wastes in suitable reservoirs, followed by their discharge into the stream or the city sewer system. A short period of storage will permit an adjustment of the rate of release to correspond with the ability of the sewage plant or the receiving stream to dilute the wastes satisfactorily and will prevent the discharge of "slugs" of brine. Storage over a long period will involve holding the brine in suitable reservoirs until adequate dilution water becomes available.

If limiting values for the various constituents found in zeolite wastes are established for a given stream, the flow necessary to dilute the wastes may be formulated in terms of the concentration of the constituent normally present in the stream, the concentration of the constituent in the brine to be discharged, the brine flow rate and the maximum allowable concentration of the constituent (after complete mixing) downstream from the point of brine discharge. Using the chloride concentration as an example, the formula is:

$$Q = \frac{q(B - C)}{C - A}$$

in which Q is the stream flow rate, in any convenient units; q is the brine flow rate, in the same units as for Q; A is the normal chloride concentration of the stream, in parts per million or other convenient concentration units; B is the chloride concentration of brine, in the same units as for A; and C is the maximum allowable concentration of chloride in the stream, in the same units as for A and B.

The disadvantages of this type of disposal lie in the cost of storage reservoirs and in the control of releases. Failure to build the reservoirs large enough to handle the quantity of brine produced during a period of low stream flow will inevitably result in the discharge of brine into the natural drainage at a time when the amount of dilution water is inadequate. Savings on storage reservoir capacity might be effected by temporarily storing only that portion of the zeolite wash water which has a high mineral concentration and releasing the remainder of the water into a suitable stream or into a sewer system.

4. *Brine disposal wells.* Brine disposal wells may offer a means for handling wastes but probably only for a limited number of zeolite plants. Experience has shown such wells to be a very satisfactory method for disposing of large quantities of brine from oil wells. Brine separated from the oil is gathered in specially constructed pipe systems (cement-asbestos or clay pipe) and, if suitable for direct disposal, is conducted to a brine disposal well. If the brine requires treatment prior to disposal, it is brought to a plant where it can be conditioned for injection. Brine treatment may involve one or more of the standard water treatment processes, such as aeration, coagulation, sedimentation and filtration. Treatment is often necessary to prevent suspended matter from plugging the pores of the formation which is to receive the brine.

Brine disposal wells may vary from 400 to 5,000 ft. in depth (5), depending upon the geology of the region. The average depth of Kansas wells is approximately 1,200 ft.

Disposal wells must be constructed carefully to avoid contaminating fresh-water horizons. Usually a 10- or 12-in. steel casing is set below all known fresh-water horizons and grouted throughout its length by the Halliburton method. The bottom plug is then drilled out and a 9-in. hole is drilled down to the top of the receiving formation. This hole is also cased and grouted and the inner casing is carried to the surface. Next the plug in the bottom of the 9-in. casing is drilled out and an open hole carried into and through the formation which is to receive the brine. The open hole may vary in depth from a minimum of 30–40 ft. up to a maximum of 400–500 ft. Cement-lined steel tubing (5–6¼ in.) carries the brine from the well head to the top of the porous formation. An open hole extends from 50 to 500 ft. below the tubing. If the receiving formation is subject to caving, the tubing is gun-perforated with ½–¾-in. holes and is carried through the formation.

Properly constructed brine disposal wells cost approximately $3.50 per foot for wells of minimum depth (400 ft.), $5.00 per foot (1946 costs) for wells of average depth (1,200 ft.) and $6.00 per foot for wells of maximum depth (about 5,000 ft.). The outlay for oil brine disposal by this method varies considerably. In a large, well

organized brine disposal association set up to handle the salt water from 300–400 oil wells, the entire cost, including fixed charges, ranges from 0.8¢–3.0¢ per 42-gal. barrel of brine (5).

A serious problem arises when brine disposal formations become plugged with corrosion products, so that it is absolutely essential to avoid corrosion of the gathering and injection pipes. Suspended matter in the brine must be removed prior to disposal, and the brine should be conditioned so that it does not react with the receiving formation to produce precipitation.

The wastes from a zeolite plant probably would have to be treated prior to injection if the water softened contained appreciable quantities of iron and manganese.

Conclusions

Controlled dilution appears to offer the most generally applicable means of handling the wastes from zeolite softening plants, but this method will be unsatisfactory unless ample dilution water is available at the time of brine release and unless the releases are carefully controlled. Uncontrolled dilution will be a less satisfactory method, although it may work for small cities located near large streams. Evaporation usually will not offer a practicable solution to the problem. Brine disposal wells may offer a satisfactory answer to the problem if the volume of wastes is large and the subsurface geology suitable for underground disposal.

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APPENDIX

Planning for Brine Disposal

In planning for the disposal of wastes from a cation-exchange softening plant, the engineer should first prepare an accurate estimate of the probable volume and composition of the wastes. Allowances should be made for future expansion if it appears reasonably probable. Following this, consideration should be given to the various disposal possibilities. At an early stage in the planning, the state agency responsible for water pollution control should be consulted. The studies involved in reaching a decision on the best means of disposal should be incorporated in the engineer's preliminary report on the project. The final report and plans should indicate in detail just how the wastes are to be handled.

The following check list is indicative of points to be considered in planning for the disposal of waste from cation-exchange softening plants.

1. *Volume of Wastes to Be Disposed of Daily:*

a. Present volume
b. Future volume

2. *Flow Rates:*

a. Present:

(1) Average
(2) Peak

b. Future:

(1) Average
(2) Peak

3. *Composition of Wastes:*

a. Present
b. Future

4. *Discussion With State Water Pollution Control Agency*

5. *Method of Disposal:*

a. Dilution (controlled, uncontrolled) direct to stream:

(1) Important, existing or future downstream water uses
(2) Stream discharge data:

(a) Seasonal variation
(b) Low flow frequency

(3) Chemical character of receiving stream:

(a) Chloride
(b) Hardness
(c) Dissolved solids, etc.

(4) Computed effect of brine wastes on chemical composition of stream under various assumed flow conditions
(5) Structures, pipe and equipment needed
(6) Costs—capital, annual
(7) Operating procedure
(8) Approval by proper state agencies

b. Dilution (controlled, uncontrolled) to stream via sewer system (Consider Items 1–7 under 5*a* and, in addition, the following):

(1) Peak rates of flow of sewage and brine (present and future)
(2) Capacity of sewers
(3) Dilution of brine by sewage before reaching pumping station or sewage treatment plant
(4) Adverse effects, if any, of wastes after dilution by sewage

(a) Sewers
(b) Pumping Stations
(c) Sewage treatment plant
(d) Receiving stream

(5) Approval by sewerage authority and state agencies

c. Brine disposal well:

(1) What has been experience in this area with this type of disposal?
(2) Subsurface geology and ground water resources
(3) Will quality of ground water be protected?
(4) Will wastes require treatment before discharge to well?
(5) Are drilling contractors capable of handling this type of work?
(6) Costs—capital, annual
(7) Approval by various state agencies

Two-Story Flocculation-Sedimentation Basin for the Washington Aqueduct

By Edwin A. Schmitt and Otto D. Voigt

A revision of a paper presented on Oct. 21, 1948, at the Joint Meeting of the Four States and Western Pennsylvania Sections, Philadelphia, by Edwin A. Schmitt, Head Engr., Chief of Water Supply Div., and Otto D. Voigt, Sr. Civ. Engr., Head of Water Supply Planning; both of the Washington Aqueduct Div. of the Washington Dist. Office, Corps of Engrs., U.S. Army, Washington, D.C.

THE first of four large, two-story flocculation-sedimentation basins is nearing completion at the Dalecarlia filter plant of the Washington Aqueduct, the supply division of the national capital's water works. Although there are several two-story basins now extant, it is believed that those at Dalecarlia will be the largest and that they embody unique features.

In a previous article (1), the authors described a comprehensive program for the construction of improvements and additions to the water system of the District of Columbia and environs. This program, presented in a report (2) approved jointly by the Chief of Engineers, U.S. Army, and the Board of Commissioners of the District of Columbia, outlined the future supply, purification and distribution improvements to the entire water supply system, including provisions for increasing the nominal capacity of the Dalecarlia rapid sand filter plant to 217 mgd. and the McMillan slow sand filter plant to 125 mgd.

In the report, the basins, a part of the Dalecarlia improvements shown in Fig. 1, are described only in general terms, and, with the completion of Basin No. 4 in June 1949, a more detailed description now is deemed of interest.

These basins were conceived first as long, single-story structures, giving a retention period of four hours at the future nominal capacity of 217 mgd. for the enlarged Dalecarlia filter plant. In the latter part of 1943 it was decided to design the basins with two stories to avoid the necessity of acquiring costly improved suburban property, to increase the retention period from four to well over five hours on nominal plant capacity and to secure satisfactory results with an adequately flocculated and settled water when operating at 25 per cent above nominal capacity.

Raw water, drawn from the Potomac River 9 miles from the filter plant, is passed first through the Dalecarlia receiving or presedimentation reservoir, where some natural settlement takes place. After this settlement, the raw water varies in turbidity from 5 to 3,000 ppm., with an average of 80 ppm.; the bacteria counts vary from 20 to 89,000 per milliliter, averaging 1,800; and the pH varies from 6.5 to 9.1, with an average of 7.7. At low turbidities, practically all suspended matter remaining in the raw water is in colloidal form.

The coagulant used for settling the water is aluminum sulfate in syrup form, which is manufactured at the Dalecarlia plant. Prechlorination is used to burn out taste- and odor-producing organic matter.

Basin Features

Basin No. 4 was designed to obtain the maximum detention period with the lowest velocity within the limits imposed by the available land area and subsurface geologic strata. The whole project consists of a control chamber and closed channels with valves for controlling the flow of water through the influent or distributing ports, a flocculation basin, a dry well and a two-story sedimentation basin with a blowoff pipeline. The raw-water supply conduits will contain flash mixers.

Based upon the future nominal capacity of 217 mgd. for the Dalecarlia filter plant, the influent and distributing channels for the basins were designed so that the average velocity of the raw water will not exceed a maximum of 2.5 fps. Water from the distributing channels will be conducted uniformly to the flocculation basin by means of rectangular ports.

The flocculation section of the basin, shown in Fig. 2 and 3, is 108 ft. long in the direction of the flow of water, 126 ft. wide and 17 ft deep. The capacity is 1.64 mil.gal., giving a volumetric retention period of 45 minutes and an average velocity of 2.6 fpm.

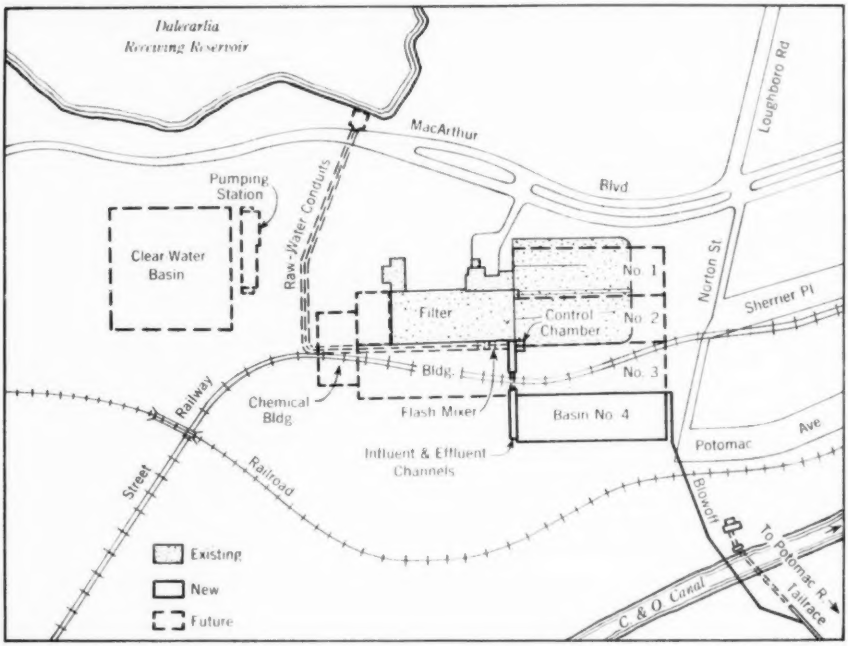


Fig. 1. Dalecarlia Improvements

This basin is equipped with six rows of Dorrco flocculators * with 14-ft.-diameter paddles operating transversely to the direction of the flow of water. The flocculators are driven by

* Made by The Dorr Co., New York.

constant-speed units, but sprockets of different sizes will permit speeds of 1.2 or 0.9 fps., measured at the periphery of the paddles. Two baffle walls are provided to prevent the short-circuiting of water across the flocculators. The driving mechanism for the flocculators is in a center dry well. The curtain wall separating the flocculation basin from the sedimentation basin will be provided with vertical ports or slots to streamline the flow of water into the sedimentation basin.

giving a volumetric retention period of 5.4 hours and an average velocity of flow of 2.4 fpm. at the nominal plant rating.

Water from the lower story will pass vertically to the upper story through seven large openings, 17 ft. 6 in. by 14 ft. 9 in., located at the far end of the basin. Settled water in the upper story then flows in a reverse direction, passing through six 4-ft. by 4-ft. sluice gates into the effluent channel leading to the filters.

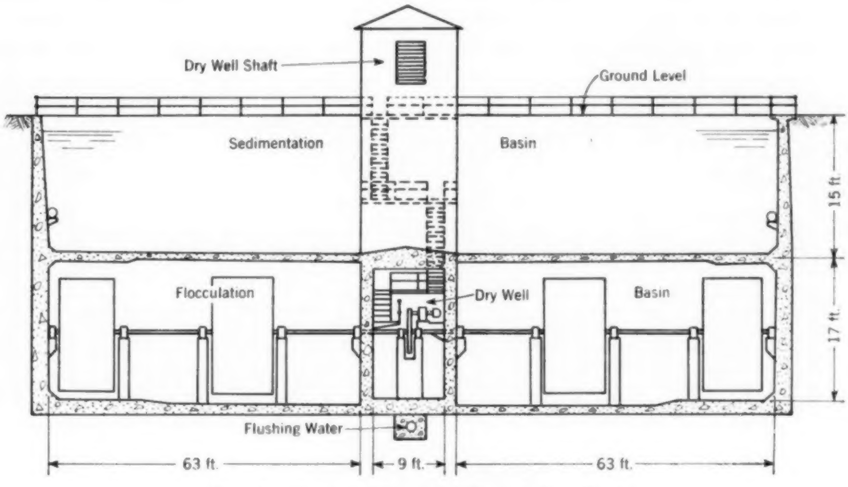


FIG. 2. Section Through Flocculation Basin

The sedimentation section of the basin, shown in Fig. 3 and 4, consisting of a first and a second story, has a total length of 776 ft. in the direction of the flow of water, 316 ft. in the lower story and 460 ft. in the upper story; a width of 138 ft.; and a depth in the lower story of 17.0 ft. and in the upper, of 15.0 ft. to normal water level. The greater depth of the lower story is to allow for the increased accumulation of sediment before cleaning becomes necessary.

The capacity of the sedimentation section of the basin is 12,074,000 gal.,

The blowoff pipeline for draining off water and sludge is 700 ft. long and discharges into the tailrace of the existing hydroelectric plant, which, in turn, empties into the Potomac River. The blowoff line is constructed of 36-in. reinforced-concrete pipe to a high embankment, and, from this point onward, down a steep slope, it is made of 30-in. steel pipe, suitably anchored with concrete thrust blocks and joined with lugged Dresser couplings. At the crest of the embankment, where the concrete pipe joins the steel pipe, there is a small chamber with an air shaft to

admit air into the line if a critical velocity is reached tending to produce vacuum conditions.

During the low winter demand on the filter plant the differential between the Dalecarlia receiving reservoir and the filters is such that flooding of the filter plant might occur, and, although the system is controlled adequately with valves, an overflow weir spilling to the blowoff line is provided as a safety measure.

A shaft and a penthouse with a metal stairway are provided over the north end of the dry well, and another structure over the south end of the dry well constitutes an escape shaft with a ladder and a ventilator and fan to keep the air in the dry well fresh, especially when maintenance crews are working. All operating controls for the flocculators are located on the entrance floor of the penthouse, which is reached by a short bridge from the effluent-channel deck.

The basin is equipped with sight inspection flumes, through which the water from the lower story will pass upward to the surface of the water in the upper story and from which samples of the lower-story floc can be obtained.

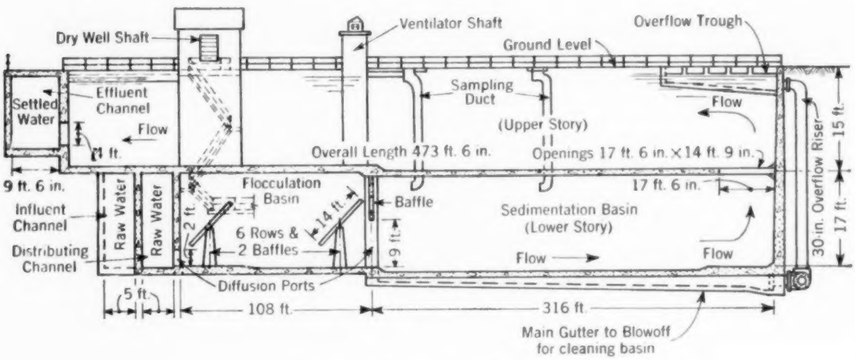


FIG. 3. Longitudinal Section

These flumes are designed to utilize velocity head in causing upward flow and are, in effect, large pitot tubes.

Safety pipe railings will be installed on the top of the walls of the basin, around the passageways to the sight inspection flumes and around the central gutter in the lower story. These railings and all other miscellaneous metal items, such as ladders and gratings, which are exposed to water or moisture will be constructed of galvanized genuine wrought iron.

Figure 5 is a photograph of the upper floor of the sedimentation basin, showing the penthouse over the stairwell, the vent stack and escape shaft over the dry well and the floc inspection flume just beyond the vent stack.

The top of the sedimentation basin is not covered, as the winter temperatures of Washington are not usually severe. Ice has caused no trouble in the existing sedimentation basins since the outer walls are sloping. To avoid possible ice expansion against the vertical cantilever walls of the new basins, a small pipeline will be supported about 6 in. below the water surface entirely around the basin perimeter. During the extreme low temperatures water or

air bubbles expelled through jets in the pipeline will prevent ice formation at the walls.

Ample electrical outlets are provided in the dry well for light and power, and around the sedimentation basin for light and for power when mechanical equipment is used to work the sludge from the side walls to the central gutter and when repairs are required.

Cleaning of Basin

For the past twenty years the Washington Aqueduct has been using successfully a method of cleaning one 250 × 1,200-ft. sedimentation basin at the Georgetown reservoir and two 154 × 345-ft. sedimentation basins at Dalecarlia by drawing down the water in stages, supplementary flushing and high-pressure hand hosing. Because of this successful operation, permanently installed mechanical scraping equipment was omitted purposely from the new basins to avoid maintenance problems which might occur with such equipment and, at the same time, to effect a considerable saving in cost without sacrificing efficiency.

The lower floor of the basin slopes downward from the side walls to the central gutter 2.6 ft. in 69 ft., while the upper floor, where the silt deposit will be appreciably less and of thinner consistency, has a downward slope of 2 ft. in 69 ft. toward the center. These slopes facilitate the cleaning of the basin.

With prechlorination of the raw water, the accumulating sludge deposits do not become septic for a period of one or more months between the seasonal cleaning schedules. When a predetermined loss of depth occurs, the basins will be drained, and flushed and cleaned with high-pressure water streams. This cleaning is accomplished ordinarily within a 24-hour period.

Low-pressure water to assist in the cleaning process is taken from the influent and distributing channels and passed under the dry well into the main gutter to wash out the sludge. In addition to flushing water, a complete, high-pressure, looped piping system will be installed on each story, from which connections can be made to hose

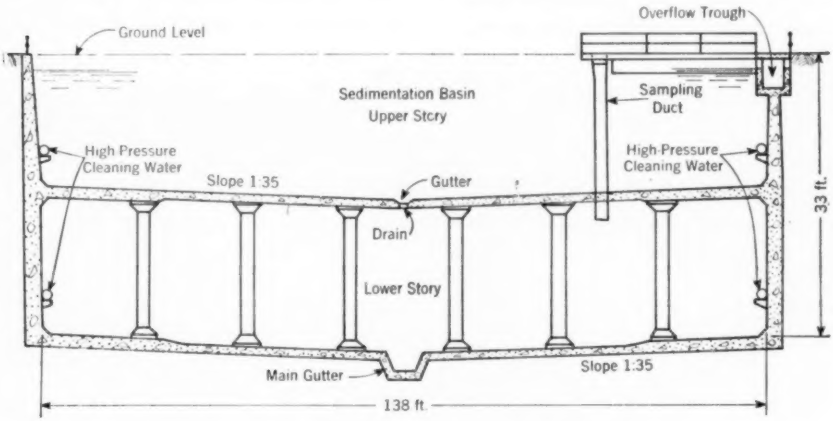


FIG. 4. Section Through Sedimentation Basin

the side walls and floors and do a thorough cleaning job.

Should the sludge deposits, through enforced deferment of cleaning, stiffen up, a light tractor with a scraper blade will be used to assist in moving the sludge to the drain gutter. Only a few men are required for the operation and, with multiple basins, no supply troubles will be experienced.

Structural Design

The design of the flocculation-sedimentation basin embodies the full use of past experience in designing other Washington Aqueduct structures, of desirable features noted during the inspection of filter plant facilities in other cities, and of new practices which the Corps of Engineers has developed for heavy construction.

The basin was designed for the following conditions of loading: the basin empty, with full earth pressure, the earth being assumed to weigh 110 lb. per cubic foot with an angle of internal friction of 25 deg.; the basin full and no counteracting earth pressure from ground grade down to the intermediate or second-story floor slab, based upon the probability that the backfill will shrink from the wall; and the counteracting effect of the backfill below the intermediate slab, with the earth above acting as surcharge and assumed to weigh 100 lb. per cubic foot with an angle of internal friction of 35 deg. The intermediate slab was designed assuming the reservoir empty, with an accumulated mud load of 50 psf. plus an ice load of 90 psf., giving a total load of 140 psf.

Because of the variation in foundation material and to counteract any adverse effect of subsurface water, it was decided to reduce the allowable unit stresses proposed by the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete * (1940) in the ratio of 0.40 to 0.45. This decision was approved by the Chief of Engineers.

Fig. 5. Upper Floor of Sedimentation Basin

The basin was designed for flat-slab construction, assuming the bottom slab distributing the vertical load uniformly over a flexible foundation. This plan resulted in a reversed flat slab for the bottom, eliminating the effect of isolated depressions for column footings. The lower part of the exterior wall was designed as a part of the first-

* Affiliated organizations include the Am. Concrete Inst., Am. Inst. of Architects, Am. Railway Eng. Assn., A.S.C.E., A.S.T.M. and Portland Cement Assn.

story rigid frame composed of lower and intermediate slabs, columns and walls. The upper part of the exterior wall was designed as a cantilever above the first-story rigid-frame wall.

The rigid-frame analysis for the entire basin resulted in heavier slabs at the exterior bays with the extra thickness at the upper part of the slab, leaving the underside level throughout. The columns were designed without top and bottom drop panels to facilitate the cleaning operations and to prevent unnecessary obstacles to the smooth flow of the water. For the same reasons, all junctions of wall and slab were provided with 6-in. fillets.

The sedimentation basin has only one expansion joint—in the east-west direction—which divides the basin into two lengths of approximately 212 ft.

It is to be noted that the formation of the expansion joint is different from the usual practice. Ordinarily, the expansion joints are located at column lines where double columns and double beams or girders are provided to take care of the end conditions. In the present design, the expansion joint was located at midspan and the adjacent slabs were designed as cantilevers with thickened column bands of the slab for support. The cross section of the basin is thus left practically unaltered, except for a 4-in. thickening of the upper column band which, having a flat chamfer, will not have a disturbing effect upon the flow of the water.

Other expansion joints are provided at the north end of the basin, around the control chamber, around the influent and effluent channels which are on two different levels, and at places where the basin facilities are to be extended in the future.

All expansion joints consist of standard crimped-copper water stops and expansion joint material. Continuous wrought-iron plate water stops are located at all construction joints in the walls and bottom slab.

As the basin is built largely upon seamy rock, a complete underdrain system paralleling the side walls and central gutter is provided to prevent the possibility of upward pressure against the lower floor slab when the basin is drained and also to drain off any leakage which might occur through the floor and walls. The underdrain system consists of perforated 8-in. cement-asbestos pipe embedded in a filter of gravel and ordinary concrete sand.

Air-entrained concrete, used in the construction of the basin, was adopted upon the recommendation of the Office of the Chief of Engineers as offering certain desirable characteristics not available with conventional concrete. These characteristics are: better workability at low slumps, a fatter mixture, greater resistance to the passage of moisture, greater durability, and higher resistance against freezing-and-thawing cycles. The cover for the main reinforcing steel for concrete surfaces in contact with water is 2½ in.

Quantities and Costs

Bids for the construction of Basin No. 4 were solicited in January 1947 and active interest was shown by contractors, as indicated by the receipt of ten complete bids in February 1947. Because the low bid of $890,070 was greater than the funds available, however, all bids had to be rejected. To bring the cost of the structure within the limit of the available funds, the contract drawings were revised with the flocculation basin shortened by two bays, or 36 ft. On August 4, 1947, the low bid of $831,097 was accepted.

The quantities of construction materials and unit costs are as follows:

excavation (unclassified), 82,000 cu.yd. at $3.30; backfill, 7,400 cu.yd. at $2.00; concrete in place, exclusive of Portland cement and steel reinforcement, 9,000 cu.yd. at $32.60; steel reinforcement, 1,850,000 lb. at $0.0622; Portland cement, 12,500 bbl. at $2.63; crimped-copper water stops, 2,000 lb. at $1.50; wrought-iron water stops, 60,000 lb. at $0.24; and cement-asbestos drain pipe, 2,300 lin.ft. at $4.00.

The remaining items of the job under contract, bid on a lump-sum basis, include: the dry-well superstructure; the overflow, the blowoff and the drain-pipe extension; electrical work; pipe railing; and miscellaneous fabricated stairways, ladders and other metal work.

The total contract cost of $831,097 for the work is composed of unit cost items amounting to $753,345 and lump-sum items amounting to $77,752.

Of the approximately 82,000 cu.yd. of unclassified excavation, about 25 per cent was rock, which varied from weathered, rotten rock to hard Potomac gneiss. Disposal of the excavation was made on the Dalecarlia reservation, the average haul being ½ mile.

Because of the unevenness of the subsurface where rock was excavated, the contractor was permitted to place a leveling course of a lean-mixture concrete to support the forms and to facilitate the placing of the reinforcing steel and the pouring of the main-floor slab.

The proximity of a part of the structure to the existing filter building and the existing sedimentation basin required a cofferdam 35 ft. deep and underpinning of the building walls, and, as rock was encountered in the lower 10 ft., great care in the use of explosives was mandatory.

The lump-sum item for the blowoff includes a tunnel 70 ft. long in rock and a railroad undercrossing. The undercrossing of the Chesapeake and Ohio Canal and 140 lin.ft. of discharge pipe were built previously by the Washington Aqueduct with hired labor.

The Washington Aqueduct, with hired-labor forces, will install the flocculators, the pressure pipe in the upper and lower stories for cleaning the basin, the various sluice gates and the electrical cables which will supply the power for operating the flocculator-driving mechanism and for the lighting system. These items of equipment and materials are being purchased under supply contracts and, together with the cost of cleanup, landscaping, the canal undercrossing mentioned previously, and engineering and overhead, will cost about $278,000, making the total cost of the entire project approximately $1,109,000.

The planning, designing and preparation of contract plans and specifications for the flocculation-sedimentation basin were executed by the Engineering Branch of the Washington Aqueduct Water Supply Div. Consultations with the operating engineers were held to make certain that the best operational and maintenance features were being incorporated in the design. Site surveys, borings and foundation material analyses were performed by other branches of the Washington Dist. Office of the Corps of Engineers. Contract supervision, inspection and hired-labor work are being handled by the Construction Section of the Operations Branch of the Water Supply Div.

References

1. Schmitt, Edwin A. & Voigt, Otto D. Expansion of District of Columbia Water System. Jour. A.W.W.A., **39**:291 (April 1947).
2. Adequate Future Water Supply for the District of Columbia and Metropolitan Area. House Doc. 480, 79 Cong. 2 (1946).

Cathodic Protection Notification Procedures

Correlating Committee on Cathodic Protection

This is Bulletin Number Two, the second of a series to be prepared by the Correlating Committee on Cathodic Protection, H. H. Anderson, Chairman. Bulletin Number One, containing management information on "Cathodic Protection of Buried Metallic Structures Against Corrosion," appeared in the May 1948 Journal (Vol. 40, p. 485).

BULLETIN Number One has described the stray-current problem arising out of cathodic protection and the need for a "good-neighbor policy" in dealing with it. Concerning these matters the bulletin states:

> Some of the current introduced at the anodes to protect one structure cathodically may enter a neighboring structure and traverse it for a distance while enroute to the protected one. Where this current leaves the neighboring structure and enters the soil, corrosion occurs which is similar to street-railway stray-current electrolysis. It can be prevented in several ways, one of the commonest of which is to connect the neighboring structure to the protected one by a wire "drainage bond" of proper resistance.
>
> Because of this possibility of interference, any operator planning a cathodic protection installation should notify operators of neighboring buried structures so that all concerned can appraise the interaction problems. Experience shows that these can be dealt with most effectively and satisfactorily through cooperative study and tests by the engineers of the operators involved.

The present bulletin further indicates the desirability for such cooperation and suggests procedures by which it can be fostered.

Advantages of Cooperation

An operator intending to install cathodic protection on his structure, or to change existing installations, will be well advised to notify neighboring structure owners of his intention. This should be done while plans are being prepared. Such notification will initiate the cooperation needed not only to assure the operator of obtaining the protection sought for his own structure, but also to give his neighbors advance opportunity to consider possible stray-current corrosion or other undesirable effects on their structures. In addition, whenever a buried line or major extension is to be newly laid or removed, whether or not cathodic protection also is planned, the neighboring structure owners should be notified, because laying or removing the line may alter the electrical conditions on existing structures.

If the notification covers a proposed cathodic protection installation, each neighbor in turn will be equally well advised to respond to the notification and, if deemed necessary, to cooperate in an engineering survey aimed to appraise the extent—if any—to which the proposed installation may affect his own structure. Also, if the survey in-

dicates that any undesirable effect is probable, the neighbor should cooperate in the engineering of preventive measures.

The advantages to be gained from taking the above-described steps before commencing installation are mutual. The installing operator will benefit because he may learn during the planning stage what preventive measures he must allow for, and thus he can predicate his design on all pertinent facts. Also, there is afforded an opportunity to determine neighboring structure conditions before they may be altered by the new installation. The neighbors will benefit because prompt response and cooperation enables suitable preventive measures to be taken at the time of the installation.

Form of Notification

Because of the wide variation in types of installation, it seems impractical to present any standard form of notification. However, to minimize later inquiry, each notification should include the following pertinent data:

1. If a buried line is to be laid or removed:

a. Size and type of construction

b. Location or route (inclusion of map or sketch is desirable)

c. Proposed dates of starting and completing construction or removal.

2. If a cathodic protection installation is proposed:

a. Number and type of current supply units contemplated

b. Location of units (inclusion of map or diagram is desirable)

c. Proposed dates of starting and completing installations

d. Designation of operator's representative to whom response should be directed, or who should be contacted in regard to joint survey and other engineering aspects.

Whom to Notify

Presuming that the above-described cooperation is sought—and that it will result from proper notification and prompt response—every operator intending to install cathodic protection, or a new line or both, or to remove a line, should determine what other structures may be exposed or affected thereby.

Depending on local conditions, the proximity of a cathodic protection system can affect buried pipelines, metal-sheathed cables, rail track systems and various other exposed metallic structures in contact with the soil. Transmission tower footings and guy wire anchors are involved occasionally. Cathodic installations also may affect the operation of railroad signal systems.

While such currents are most likely to affect merely the exposed structures which cross or are close to the protected one, they may sometimes affect others more remote. Depending on conditions, their sphere of influence may be narrow or broad.

Extent of Interaction Between Structures

A full discussion of the factors determining the extent of interaction between a cathodically protected structure and an exposed one is too technical for this bulletin. However, three factors especially deserve mention herein and careful consideration by all concerned:

1. *"Influence" of protective installation.* The tendency of the protective currents to stray to and influence neighboring exposed structures can be minimized [1] by judiciously locating the anodes; [2] by using additional and well separated anodes if necessary to

distribute the protective current reasonably and thus limit the amount introduced into the earth at any single location; and [3] by insulating or coating the protected structure so that the required protective currents—and, hence, the possible stray currents—are kept to a minimum.

2. *"Coupling" between structures.* Coupling depends on [1] earth resistivity and [2] structure separation. The higher the earth resistivity (resistance per unit cube), the greater is the area over which the protective currents will migrate. The greater the separation between the protected and exposed structures in the earth, the less is the interaction between them.

3. *"Susceptiveness" of exposed structure.* Exposed structures which are insulated by coatings, and those of poor electrical conductivity, are less likely to be affected by stray currents than are bare structures and those of high conductivity. Well insulated structures present a minimum exposure to stray currents. However, coating insulation can deteriorate in service, in which event its protective value is correspondingly reduced.

From the foregoing it appears that the factor of "influence" is substantially under the control of the designer of the protective system. Thus, in designing the system, he should use the best techniques consistent with overall economy. "Coupling" depends also on soil resistivity that cannot be controlled, but it can be minimized to the extent that, by advance planning, operators may be able to avoid the close association of their structures.

"Susceptiveness" is under the control of every operator on his own new structures, whether or not cathodic protection is used. Cathodic protection is becoming widely recognized and applied as a practicable means of reducing corrosion of buried structures. Thus, overall benefits will accrue if every operator will design and install his new plant so as to keep its susceptiveness as low as possible. This may involve, for example, the use of coatings or of insulated joints. By minimizing the exposure of the new line to stray-current corrosion, the operator also will minimize its exposure to natural corrosion!

Sources of Data

The act of proper notification obviously requires the installing operator to know also which neighbors own the other structures that may be involved. The notices preferably should be directed to operating officials presumed to have jurisdiction in such matters. In urban areas, where structures are relatively short and the neighbors are usually well known, this information should be readily obtainable. Where urban "joint electrolysis committees" exist (*see* Appendix A) such information usually can be obtained from their chairmen or secretaries. But an operator who intends to install or protect a long line traversing many miles of varied country may have greater difficulty in determining whom to notify.

To assist in this matter, certain generally available sources of data on structure locations, ownership, operating personnel and so forth are called to attention herein. (The numbers in parentheses below refer to the list of publishers given in Appendix B.)

Railroads. Several types of maps are available to show the routes of railroads. A four-sheet general map to scale 1 : 2,500,000 is the "Railroad Map of the United States" (1). Handy identity and distance maps in atlas form are also available (2, 3). The best

route alignment data generally available at nominal cost are in the maps of the U.S. Geological Survey. These include a series of state maps mostly to a scale of 1 : 1,000,000 (4a); another state map series mostly to scale of 1 : 250,000 (4b); and the many regular topographic quadrangles, varying in scale from 1 : 62,500 to 1 :24,000 (4c). Lists of rail carriers, with business addresses and names of key personnel appear in "The Pocket List of Railway Officials" (5).

Electric railways. A list of headquarter cities of electrified rail carriers, with names of carriers, their business addresses, key personnel and system data, appears in the "Mass Transportation Directory" (6). Most of the carriers issue handy maps of their systems.

Petroleum pipelines. Industry-fostered maps to scale 1 in. equal 24 miles, showing all crude-oil and products trunk pipelines in the central or eastern United States can be purchased at nominal cost (7). These maps indicate the names of the line operators. Maps of such lines in California can be obtained as of May 1949 only from private sources. Lists of most oil pipeline carriers, with business addresses and names of key personnel, appear (among other places) in the "Petroleum Register" (8) and the "Directory of Pipe Line Personnel" (9).

For the oil-producing country, where innumerable oil-gathering and field service pipelines exist, composite line maps are not usually available. However, local field maps showing the individual oil properties or "leases," and names of their operators or "producers," usually can be purchased from various sources. Field line maps of oil and gas producers, and gathering maps of the various pipeline carriers, usually can be inspected at the producers' and carriers' district, division and head offices.

Gas pipelines. A general map can be purchased, titled "Principal Natural Gas Pipe Lines of the United States" (10). Data on the location of local gas distribution lines may be obtained at the utilities' local business offices. A list of gas companies, with business addresses, names of key personnel and considerable system data appears in "Brown's Directory of American Gas Companies" (11).

Water pipelines. Most water pipelines are confined to urban areas, although there are also suburban companies and some of the larger urban systems are served by feeder lines from outlying reservoirs and the like. Data on the locations of water lines may be obtained at the operators' local business offices, or, if municipally owned systems, from the city engineer's or public works administrator's office. Lists of the city engineers, water works superintendents (where systems are municipally owned), street superintendents and superintendents of sewerage for the 1,072 cities having more than 10,000 population are listed in the *Municipal Index and Atlas* (12). Another source of water system personnel information is the membership list of the A.W.W.A.

Central steam-heating and refrigeration pipelines. Pipelines of companies furnishing steam-heating and refrigeration services are confined to a relatively few urban areas. Data on the locations of these lines may be obtained at the operators' local business offices.

Electric power cables and transmission lines. Data on the locations of electric power cables, which generally are confined to urban areas, may be obtained at the utilities' local offices. General maps of principal suburban, interurban and interstate transmission lines appear in atlas form and separately (13a, 13b). Lists of cities and

towns, with names of the electric utilities in each, and their business addresses and officials, appear in the "Central Station Directory" (14).

Communications cables—Bell System. Bell System cables may be interstate and interurban as well as urban. They are classified as "underground" if in ducts and as "buried" if plowed or trenched in. Data on their locations may be obtained from the district or division plant superintendents of the Bell System company operating in the area involved. Lists of the cities and towns served by each of these companies, their operating areas, and the business addresses and key personnel of their head offices (and sometimes of their area offices), appear in "Telephony's Directory" (15). It is proper to notify the above-mentioned superintendents concerning the involvement of local and intrastate cables. In installations involving interstate cables, the district plant superintendents of the Long-Lines Dept. of the American Telephone and Telegraph Co. should be notified. Their headquarters offices are listed in Appendix C.

Communications cables—independent telephone companies. These cables, underground or buried, may be interurban as well as urban. Data on their locations may be obtained from the offices of the companies. Lists of the cities and towns served by independent companies, with company names, business addresses and key personnel, appear in "Telephony's Directory" (15).

Communications cables—Western Union. Underground and buried cables of the Western Union Telegraph Co. are confined principally to urban areas. Data on their location may be obtained from the company's local plant and engineering department. Notification should be addressed to "Area Superintendent—Plant and Engineering."

Municipal signal systems. Underground and buried municipal signal cables are confined to urban areas. Data concerning their location may be obtained from the local offices of fire and police authorities. Lists of the fire and police chiefs of cities with more than 10,000 population appear in the *Municipal Index and Atlas* (12) and in the *Municipal Year Book* (16). A source of the names of the signal system superintendents is the membership list of the International Municipal Signal Assn.

Joint Industry Committees

Reference has been made to the existence in many urban areas of "joint electrolysis committees" through which the problems of notification and joint survey in corrosion mitigation are being handled with a minimum of effort and a maximum of cooperation. These committees usually are composed of representatives from each operator of buried structures in the area. The success which has attended their work indicates their value.

It would seem that the voluntary formation of somewhat similar committees can assist in the correlation of cathodic protection notification and survey problems in other urban areas and in nonurban areas, these latter appropriately sized according to community of interests. In some nonurban areas, there may be so many operators that it will be impractical for all of them to have individual representation on the committees. In such areas the committees perhaps can more practically be composed of one or two representatives informally selected by the interested operators in each industry concerned, thus giving the committees a composition similar to that of the Correlating Committee on Cathodic Protection.

APPENDIX A

Joint Electrolysis Committees

Electrolysis Survey Committee of Baltimore City:
Hugh H. Hunter *
Public Service Com.
Baltimore 2, Md.

Chicago Joint Electrolysis Committee of Various Utility Companies:
L. F. Greve *
Commonwealth Edison Co.
Chicago 90, Ill.

Cincinnati Committee on Electrolysis †:
Edgar Dow Gilman
City Hall
Cincinnati, Ohio

Cleveland Committee on Electrolysis:
G. R. Canning *
Ohio Bell Telephone Co.
750 Huron Road
Cleveland 15, Ohio

Denver Committee on Electrolysis:
A. M. Spaulding *
Mountain States Tel. & Tel. Co.
Denver, Colo.

Des Moines Electrolysis Committee:
Earl Olmsted *
Des Moines Gas Co.
Des Moines, Iowa

Detroit Committee on Electrolysis:
R. M. Lawall *
American Tel. & Tel. Co.
1814 Book Tower
Detroit 26, Mich.

Joint Committee for the Protection of Underground Structures in the East Bay Cities:
M. N. Clark *
Pacific Gas & Electric Co.
1625 Clay Street
Oakland 12, Calif.

Louisville Electrolysis Committee:
S. H. Gates *
Southern Bell Tel. & Tel. Co.
Box 538
Louisville, Ky.

Milwaukee Electrolysis Committee:
Glenn Chamberlain *
Milwaukee Gas Light Co.
Milwaukee, Wis.

New Haven Electrolysis Committee:
E. A. Johnson *
Southern New England Tel. Co.
227 Church Street
New Haven 6, Conn.

Greater New York Electrolysis Committee:
Sumner Hayward *
New York Telephone Co.
101 Willoughby Street
Brooklyn 1, N. Y.

Omaha-Council Bluffs Electrolysis Committee:
J. C. Detweiler *
Metropolitan Utilities Dist.
Utilities Building
Omaha, Neb.

Suburban Philadelphia Electrolysis Committee:
A. V. Smith *
370 Trevor Lane
Bala-Cynwyd, Pa.

Pittsburgh Corrosion Committee:
C. A. Erickson *
Peoples Natural Gas Co.
545 William Penn Way
Pittsburgh, Pa.

Roanoke Electrolysis Committee:
C. M. Baldock
Chesapeake & Potomac Tel. Co.
Roanoke, Va.

Sacramento Underground Joint Committee:
C. M. Hoskinson *
112 City Hall
Sacramento, Calif.

San Francisco Area Joint Committee ‡:
L. M. Perrin §
Hetch Hetchy Water Supply
San Francisco, Calif.

Electrolysis Committee of Southern California:
I. C. Dietze *
Dept. of Water & Power
Box 3669 Terminal Annex
Los Angeles 54, Calif.

Wheeling Coordinating Committee on Corrosion †:
C. F. Aulick, Jr.
C. & P. Telephone Co. of W. Va.
Wheeling, W. Va.

Youngstown Committee on Corrosion Control:
F. W. Nimer *
Ohio Edison Co.
Akron, Ohio

* Committee chairman.
† Temporarily inactive.
‡ Now being organized.
§ Acting chairman.

APPENDIX B

Publishers of Maps and Directories

1. Railroad Map of the United States (*annual*). Commanding Officer, Army Map Service, 6500 Brooks Lane, Washington 16, D.C.
2. *Handy Railroad Atlas of the United States* (*annual*). Rand McNally & Co., 536 S. Clark St., Chicago, Illinois.
3. *Leahy's Hotel Guide and Travel Atlas* (*annual*). American Hotel Register Co., 226 W. Ontario St., Chicago 10, Ill.
4. (a) State Index Maps, without red overprints, scale 1 : 1,000,000; (b) State Maps to four times scale of Index Maps, scale 1 : 250,000; (c) U.S. Topographic Quadrangles, various scales. Director, U.S. Geological Survey, Washington 25, D.C.
5. The Pocket List of Railway Officials (*quarterly*). Railway Equipment & Publishing Co., 424 W. 55th St., New York, N.Y.
6. Mass Transportation Directory (*annual*). Kenfield-Davis Publishing Co., 608 S. Dearborn St., Chicago 5, Ill.
7. Maps of petroleum pipelines in (a) "Central United States" or (b) "Eastern United States" (*kept up-to-date*). L. L. Ridgway Co., 615 Caroline St., Houston, Tex.
8. Petroleum Register (*annual*). Mona Palmer, 794 Stanford Ave., Los Angeles 21, Calif.
9. Directory of Pipe Line Personnel. Midwest Oil Register, Box 892, Tulsa, Okla.
10. Map of "Principal Natural Gas Pipe Lines of the United States." Federal Power Com., Washington, D.C.
11. Brown's Directory of American Gas Companies (*annual*). Moore Publishing Co., 9 East 38th St., New York, N.Y.
12. *Municipal Index and Atlas* (*annual*). American City Magazine Corp., 470 Fourth Ave., New York 16, N.Y.
13. (a) Maps of "Principal Electric Facilities in the United States" (*complete coverage in atlas form*); (b) maps of "Principal Electric Utility Generating Stations and Transmission Lines" (*separate maps for eleven regions and six congested areas*). Federal Power Com., Washington, D.C.
14. Central Station Directory (*annual*). McGraw-Hill Publishing Co., Inc., 330 W. 42nd St., New York, N.Y.
15. Telephony's Directory (*annual*). Telephony Publishing Corp., 608 S. Dearborn St., Chicago, Ill.
16. *Municipal Year Book* (*annual*). Intl. City Mgrs'. Assn., 1313 E. 60th St., Chicago, Ill.

APPENDIX C

American Telephone and Telegraph Co. District Offices (Long-Lines Department)

Alabama: 703 Comer Bldg., Birmingham 3

Colorado: 931—14th St., Denver 2

Connecticut: Box 31, West Haven 16

District of Columbia: 1809 G Street, N.W., Washington

Florida: 1130 Lynch Bldg., Jacksonville 2

Georgia: 51 Ivy St., Atlanta 3

Illinois: 7 East Clinton St., Joliet; 422 S. 5th St., Springfield

Indiana: 240 N. Meridian St., Indianapolis 4

Massachusetts: 125 Milk St., Boston 9

Michigan: 1814 Book Tower, Detroit 26

Minnesota: 420 3rd Ave., Minneapolis 2

Missouri: 1426 Locust St., Kansas City 6; 2651 Olive St., St. Louis 3

Nebraska: 723 Service Life Bldg., 1904 Farnum St., Omaha 2

New Jersey: 1106 National Newark Bldg., 744 Broad St., Newark 2

New Mexico: 300 W. Copper Ave., Albuquerque

New York: 158 State St., Albany 1; 51 Erie St., Buffalo 2

N. Carolina: 208 N. Caldwell St., Charlotte

Ohio: 209 W. 7th St., Cincinnati 2; 750 Huron Rd., Cleveland 15

Pennsylvania: 124 Pine St., Harrisburg; 648 Bourse Bldg., Philadelphia 6; 416—7th Ave., Pittsburgh 19

Tennessee: 1113 Nashville Trust Bldg., Nashville 3

Texas: 4100 Bryan St., Dallas 4

Virginia: 1120 Central National Bank Bldg., Richmond 19

Joint Cathodic Protection Systems

Correlating Committee on Cathodic Protection

This is Bulletin Number Four of a series prepared by the Correlating Committee on Cathodic Protection, H. H. Anderson, Chairman. Bulletin Number One was published in the May 1948 Journal (Vol. 40, p. 485), and Bulletin Number Two appears in the present issue (p. 845). "Technical Practices in Cathodic Protection," scheduled as Bulletin Number Three, is in process.

BULLETINS Number One and Two have pointed out that external currents, beneficially impressed for the protection of a buried metallic structure, can stray through the soil and cause corrosion or other undesirable effects on neighboring structures. It was further stated that these adverse effects can be prevented—for example, by connecting the neighboring structures to the protected one with wire bonds of proper resistance. Thus, the bulletins stressed the need for cooperation among the structure owners so that these preventive measures can be properly engineered and applied.

The previous bulletins have also pointed out that, where neighboring structures of two or more operators are subject to similar natural corrosion damage, "joint cathodic protection systems" can be designed, installed and operated economically to the benefit and satisfaction of all concerned. The present bulletin gives further information about these joint systems. It discusses the techniques of their design and installation, and possible divisions of responsibility for their construction, operation and maintenance; and the sharing of costs. Also, it presents an outline of the principal points that may be included in any agreement between the structure owners.

Value of Joint Systems

The idea of joint cathodic protection is not unique. It follows the economically sound principles of the joint solution of local corrosion problems so well developed during the last three decades in metropolitan areas by "joint electrolysis committees."

The economy of joint cathodic protection on neighboring structures is evident. Assume that Operator *A* owns a line which traverses an area of corrosive soil and that—aware of this fact —he decides to install cathodic protection on his line. Assume also that Operator *B* owns a neighboring line that is similarly threatened by natural corrosion but that he has no such preventive measures in mind.

Suppose that *A* proceeds alone to protect his line. In this event, his impressed protective currents then may migrate into *B*'s line and cause electrolytic corrosion at the points whence they leave to return into *A*'s line. Sometimes this condition can be corrected by a change in the design of *A*'s installation. Otherwise such correction may require, for example, bonding the two lines together with a wire of proper resistance. The installation of such a bond and the resultant use of additional current will increase *A*'s

costs without providing to *B*'s line any substantial protection against natural corrosion.

Suppose that *B*, now also concerned about natural corrosion, decides to install cathodic protection independently on his line. His impressed currents in turn may adversely affect *A*'s line unless other or different bonds are installed. Thus, when each party attempts an individual solution, installation costs and operating costs for both are increased. This causes economic waste.

Such a situation calls for joint cathodic protection at the outset. If *A* and *B* will jointly engineer, install and operate such a system, both lines can be even more effectively protected. Furthermore, this can be accomplished with total capital and operating costs substantially less than the total costs of two individual systems, even if these were installed without regard to their mutual interference. By equitably sharing the joint costs, *A* and *B* both can enjoy maximum protection at minimum cost. This insures maximum economic gain.

While this bulletin does not treat instances in which the protection of one structure affects conditions on a neighboring structure not requiring similar protection, such eventualities also are best dealt with by full cooperation and mutual appreciation of the problem. The need for these attitudes was made clear in Bulletin Number One.

The present bulletin will perhaps find its widest application in open country where the neighboring structures involved are continuous and cross infrequently. However, the same cooperative approach is even more desirable in developed areas having more complex structure layouts, which create more difficult technical problems.

Joint System Design

The design of a joint cathodic protection system, including each subinstallation, should aim to give effective protection. Also, it should aim to do this as cheaply in capital and operating costs as is practicable, considering all structures or lines involved. To accomplish this end, several fundamentals should be kept in mind:

1. The engineer of each participating structure owner should be the sole judge of his structure's own protection requirements.
2. Joint tests should be made to determine how much protective current each structure requires, taking into account the mutual reactions of all structures to such currents.
3. The wire bonding and anode system should be of ample size to handle the total current to all structures.
4. The total current should be divided among the structures in proportion to their needs.

Each of these design fundamentals is discussed briefly below:

1. *Judging requirements.* Different voltage and current conditions are required for the proper protection of different types of structures; for example, as between steel pipes and lead cables, between coated and uncoated pipes, between cables in ducts and buried cables, and so forth. Also, the techniques of testing for and prescribing such requirements are still being developed. Thus, different engineers may use different protection criteria. Joint studies and tests can proceed best when each participant's engineer is free to state and use his own criteria.

2. *Joint tests.* Different engineers will often wish to use different testing techniques and instruments. However, because the changes in potentials of and

currents in the various structures are interdependent, any tests made by individual participants must be coordinated into a joint result. This usually can be effected informally by the engineers.

3. *Overall design.* The coordinated result of the joint tests will indicate how much current should flow to each structure and the effective resistance presented by each to such current. After the individual requirements are known, the total protective-current demand can be found. Then, based on test data, the anode structure can be designed. The operating voltage of the rectifier or generator must be ample to impress the total protective current through the resistance of the entire electrical network. Both the current and voltage outputs of the rectifier or generator should usually have some margin for contingencies.

4. *Dividing current among structures.* The total current can be distributed by adjusting the resistances of the leads from the rectifier or generator to the several structures. These resistances can be estimated from the initial test data, but because of environment changes after the installation has been in operation for some time, subsequent adjustments usually must be made. Tests are desirable from time to time to ascertain that all needed protection is afforded.

When further studies of the techniques of cathodic protection are made and reported on, and as more experience is gained with joint installations, the prevalent variations in testing technique and protection criteria should be reconciled, thus simplifying cooperative design.

Division of Responsibility and Costs

With joint protection installations, it has proved most practical for one participant to own and maintain the rectifier or generator, the anode structure and all other equipment common to all protected structures. Conversely, each participant preferably should own and maintain the wires, connections and the like serving only his own structure.

The participant who can most readily and efficiently do the job should normally build, own and maintain the common parts of the installation. However, a fair division of the common initial, fixed, maintenance and power costs must be worked out among all participants. Although conditions will vary widely, such a fair division can always be determined by analysis of the equities.

The agreed arrangement for the division of costs should be flexible enough to accommodate later desirable changes in the total protective current or current distribution. Sometimes such flexibility has been promoted by agreement of the participants to share the annual costs equally rather than to recompute such costs with each minor change in plant or current use. In other instances, the participants have agreed to share such costs on the basis of the distribution of current flow. For clarity, these two arrangements are recited more concisely:

1. The sum of the annual (actual or estimated) fixed, maintenance and power costs of the joint installation will be divided equally among the participants.

2. The sum of the annual (actual or estimated) fixed, maintenance and power costs of the joint installation will be divided among the participants in proportion to the protective current flowing to each structure.

A compromise between these two arrangements is a third possibility for division of costs.

Agreements Between Participants

Before the testing and the installation work are begun, the participants should agree on the responsibilities of each. Generally such an agreement is reached informally on the basis that each should do his fair share. To confirm the arrangement for the division of annual costs, some more formal agreement is advisable. Frequently this can be handled by an interchange of letters or by jointly prepared memoranda recording the result of conferences.

If a general agreement seems desirable, it may include any or all of the following provisions:

1. If either party contemplates the installation of cathodic protection equipment on its underground structures in any area in which the other party also owns underground structures, it should invite the other party to join in a cooperative study of the common problem.
2. If such a study is agreed upon, both parties should cooperate in the conduct of necessary surveys, and the preparation of plans and estimates, and then decide whether or not to install and operate joint cathodic protection facilities for their common benefit.
3. If it is decided to install and operate such facilities, the parties should agree which of them shall build, own, operate and maintain the proposed joint installation. (In general, this should be the one which, under the circumstances, can perform the services at the lowest cost.) The parties should agree also on an equitable division of the annual costs—including fixed charges and operation and maintenance expenses— of operating such installation, taking into consideration estimates of annual costs, results of field tests and any other pertinent matters.
4. The party to make the joint installation should then do so in accordance with the jointly approved plan. When the installation is completed, field tests and adjustments should be made to the mutual satisfaction of both parties.
5. An arrangement should be made for billing the costs of operation at suitable intervals.
6. A record of each joint installation should be made a part of the agreement. (Appendix A indicates the data pertinent to such a record.)

APPENDIX A

Record of Joint Cathodic Protection Installation

Description and location of installation: ....

....

Installed and owned by: ....

Agreed annual costs of installation effective from ....

.... are as follows:

Fixed charges (.....% of total capitalized cost of $.....) ...... $..........

Fuel or electric energy costs ....

Other operation and maintenance costs ....

Total agreed annual costs .... $..........

Total annual costs are to be divided as follows:

.... Company .....% .... $..........

.... Company .....% ....

Total $..........

Processing Water for Industry

By R. W. Haywood Jr. and Bert H. Wells

A paper presented on May 31, 1949, at the Annual Conference, Chicago,, by R. W. Haywood Jr., Asst. San. Engr., American Viscose Corp., Philadelphia, and Bert H. Wells, Chemist, Quality Control Div., Coca-Cola Co., Atlanta, Ga.

Rayon Industry—*R. W. Haywood Jr.*

ONE of the largest users of water for industrial purposes in this country is the rayon industry. In washing the fibers after their formation, and in providing the necessary steam and power, a total of 160 gal. per pound of fiber produced is required (1). During 1948, 1,100,642,000 lb. of rayon was produced in the United States (2), with a resulting water requirement of 176,103 mil.gal.

It is the purpose of this paper to present information concerning the treatment of water used in the production of regenerated cellulose products as practiced by one manufacturer only—the American Viscose Corp. Although production facilities are divided among a number of plants located in Virginia, West Virginia and Pennsylvania, the water requirements are the same in all, and the processes used to meet them vary only slightly in one or two plants.

The raw water varies in quality, depending on the source and the location of the various plants. Most of the water comes from rivers and flowing streams, although one plant gets all of its supply from wells, while another secures part of its water from this source. The need for water of higher quality than is available from untreated supplies has dictated the type of treatment required. For certain steps in the process, the water must be free from all suspended matter, a requirement which leads logically to filtration. In washing procedures, the absence of soap-consuming compounds is desirable and sodium cycle softening is employed. In other steps, it is preferable that all dissolved, as well as suspended solids be absent, which calls for deionization or evaporation.

Filtration

Rapid sand gravity filters are used for the removal of suspended solids, the basic processes being quite similar to those employed by other industries and municipalities with the same problem. Aluminum sulfate is used as a coagulant, and, where it is necessary to supplement the natural alkaline content of the water, either caustic soda or sodium carbonate is used, lime being unacceptable. In some plants, it has been found advantageous to reduce the alkalinity by the addition of sulfuric acid during periods of the year when the alkaline salts are present in unusually high concentrations; when this is done, less alum is required for proper coagulation.

The old-style wooden-tub filters with mechanical agitation, are still in use in a number of plants. In many of these

filters, the sand remains clean and bright and free from mudballs and hard spots after years of service. In other filters, a combination air-water wash is used in which the filters are washed with a water rise of 15 in. per minute and approximately 0.7 cfm. of air per square foot of filter area, the air being delivered at a pressure of 5 psi. Filters washed with this arrangement still require attention to prevent hard spots from forming at the edges and tend to throw sand into the wash water troughs at times of full water-air flow.

Within the past year a 6-mgd. filter plant has been put into operation at the Fredericksburg, Va., manufacturing plant. (Figure 1 shows the front of the plant with the chain fall and trolley used for handling ton containers.) All chemicals are fed in solution, the rate of feed being controlled automatically by a propeller type meter in the raw-water influent line. This meter has an electrical contactor head which activates the chemical feeders.

Rate-of-flow and loss-of-head gages are used to indicate filter operation. The rate of flow in each filter is controlled manually throughout the run. The filters are washed when a definite loss of head has been reached. During the first few months of operation the wash water requirements were approximately 1–1.5 per cent, but it is hoped that this figure will be reduced as operating experience is gained. A view of the filter gallery is shown in Fig. 2, and Fig. 3 is a photograph of the sedimentation basins from the influent end, the flocculators being in the sections extending across the basin.

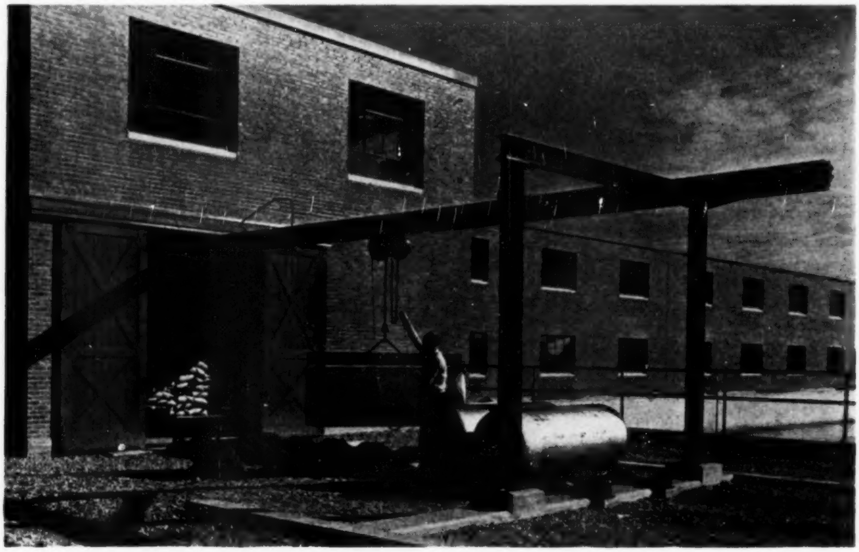


FIG. 1. Handling Ton Containers of Chlorine

Softening

A considerable volume of water is softened in sodium cycle softeners, where calcium and magnesium salts are converted to sodium salts. In general, pressure type softeners are used, ex-

cept in one plant which is equipped with gravity softeners. Although greensand zeolite has been used almost exclusively as the exchange medium until recent years, synthetic ion exchangers having a higher capacity are now being tried when more softening capacity is needed from the same equipment. They are also being considered for new installations, in view of the smaller size of equipment necessary.

Both carbonaceous and resinous exchangers have been used successfully. On one occasion, when the influent water contained residual chlorine on the order of 1.0–2.0 ppm., the carbonaceous exchanger failed, disintegrating so badly that it had to be replaced. Where chlorine residuals have not been excessive—that is, not more than 0.1–0.2 ppm.—this type of exchanger has been entirely satisfactory. The resinous exchangers have not been in service as long as the carbonaceous or greensand varieties, but, so far (after sixteen months) are giving good service.

Dissolved-Solids Removal

There is a need for water free from dissolved as well as suspended solids. This type of water is supplied by deionizing plants, where filtered water is treated to remove dissolved solids. The characteristics of the water before and after treatment are shown in Table 1.

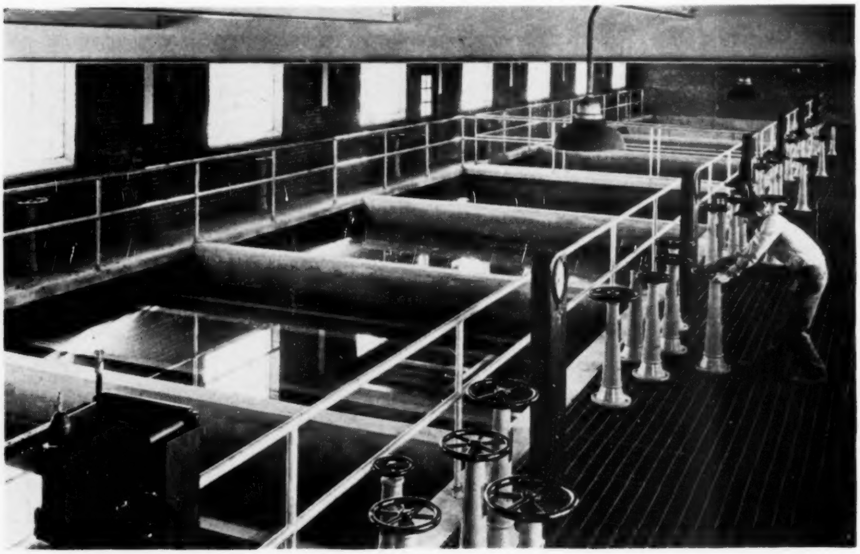


Fig. 2. Filter Gallery

One plant producing this kind of water consists of a battery of cation exchangers operating in the hydrogen cycle, followed by a battery of anion exchangers, or acid absorbers. In the first units, the sodium, calcium and magnesium ions are replaced by hydrogen ions to form the corresponding acids—that is, sodium sulfate will form sulfuric acid, calcium carbonate will form carbonic acid, sodium chloride will form hydrochloric acid and so on. The anion exchangers simply remove

TABLE 1
Water Quality

Characteristic	Filtered Water	De-ionized Water
	ppm.	
Hardness *	70	0
Alkalinity (C_aCO_3)	37	8
Acidity (C_aCO_3)	9	1
Total solids	138	8
pH	7.0	2.3

* Soap method.

the acids thus formed, leaving a water equal in purity to distilled water. Silica, however, is not removed by this process.

the unit was backwashed. The manufacturer was called in and explained that the resin was breaking down because of excessive pressures developed in the resin layer. These pressures were the result of fines being left by insufficient washing, and the condition snowballed—the more fines left, the more the loss of head increased and the more the resin disintegrated to form additional fines. The relatively simple answer was a long, hard wash to get rid of the fines and sufficient washing to keep them out.

FIG. 3. Sedimentation Basins

To reactivate the exchangers, the cation-exchange unit has a charge of sulfuric acid passed through it, the excess being rinsed out before the unit is put back into service. The anion exchanger is regenerated in the same manner, except that sodium carbonate or sodium hydroxide is used as the regenerant chemical.

Trouble was experienced with an anion exchanger on one occasion—the unit would not operate at the designed and guaranteed rate. In addition, quantities of the resin were lost each time

One other method which is used to provide solids-free water is evaporation. Operating on the basis of a large still, water is converted to steam and condensed to solids-free water equal to, but not surpassing, de-ionized water in purity. Although the two types of treatment produce water of equal quality, the distilled-water costs are ten times those of de-ionized water when evaporators are used for this purpose alone. This differential is greatly reduced if the evaporators are employed as pressure-reducing valves

to provide low-pressure steam for plant use.

It can be seen that, although the rayon industry uses large quantities of water, the treatment problems differ but slightly from those of other industries. As process refinements require better water, the methods of water treatment must be constantly reviewed, modified and improved. The foregoing description, however, has outlined the methods of water treatment now in use by one of the largest manufacturers of rayon and other regenerated cellulose products in the world.

References

1. JORDAN, HARRY E. Industrial Requirements for Water. Jour. A.W.W.A. **38**: 67 (Jan. 1946).
2. ANON. Textile Fiber Consumption. Rayon Organon, **20**:3:35 (1949).

Carbonated-Beverage Industry—*Bert H. Wells*

The soft drink business is big business. It is the country's largest industrial user of sugar, consuming over 1¼ billion pounds a year. It uses about 50,000 trucks, requiring 75 mil.gal. of gasoline a year, to deliver its products to 1,250,000 retail outlets.

The industry uses approximately 6.25 bil.gal. of water a year in approximately 6,000 syrup and bottling plants. Slightly over a dozen bottling plants in various parts of the country use as much as 50 mil.gal. of water a year—about enough to supply a town of 2,500 inhabitants.

Those who have been associated with the beverage industry for a number of years have observed the continuous improvements in municipal water supplies. In practically every city and town in this country today, it is taken for granted that the water is clean and wholesome. But safe, clear, potable water may not always be satisfactory for bottling carbonated beverages, and water is one of the most important ingredients. For example, there is a threshold for alkalinity; clarity is a critical factor; the presence of chlorine or other taste- or odor-producing substances is not permissible.

Water Quality Problems

Though the alkalinity of drinking water usually does not affect its wholesomeness or taste, high alkalinity has a marked deleterious effect on an acidified carbonated beverage. The acidulants most generally used in such beverages are citric or phosphoric acid. The tartness imparted to the beverage by these acids is due to the acids themselves—the acid salts are not tart or sour. Thus, if there is sufficient alkaline material present to neutralize the first hydrogen ion, the tartness of the beverage is lost. In a beverage containing phosphoric acid, the tartness is seriously affected when 170 ppm. of alkalinity is present and is completely destroyed if the water contains as much as 340 ppm. It is preferable to use water with an alkalinity below 85 ppm.

In addition to excessive alkalinity, even the occasional presence of some other substances may cause difficulties. Bottle filling is a highly sensitive operation. Syrup, carbonated water and bottles, all at different temperatures, are brought together, with the requirement that uniform carbonation and filling height be obtained. Waters which appear to be clear may contain sufficient finely divided solid material to cause filling difficulties. During the filling operation the bottles containing syrup and carbonated water are open as they travel from the filler to the crowner, where the caps or crowns are applied. The presence of finely divided solid

material may cause foaming, resulting in excessive loss of carbonation. Tastes and odors in the water may affect the taste quality of the finished beverage. Organic matter, including algae, may cause flocculation or sedimentation of some of the components of the beverage or produce objectionable tastes. Excessive hardness in the water may precipitate in the bottle-washing solutions, resulting in cloudy bottles and scale formation on the moving parts and heating coils of the bottle-washing machine.

Different types of water and different conditions are encountered in various sections of the country. Figure 4 presents an approximate picture of this situation. The zones of alkalinity shown represent the waters received by the various bottling plants, rather than the alkalinities of the natural supplies. Not shown are a few localities where the waters contain sufficient amounts of sulfates and chlorides to give them a marked saline taste. These waters must either be distilled or treated by ion-exchange equipment.

Generally, methods of water treatment in bottling plants are similar, though most of the so-called parent companies frequently have individual ideas or requirements. Naturally, the author is more familiar with the requirements and methods of the company which he represents, but they are probably representative of the industry.

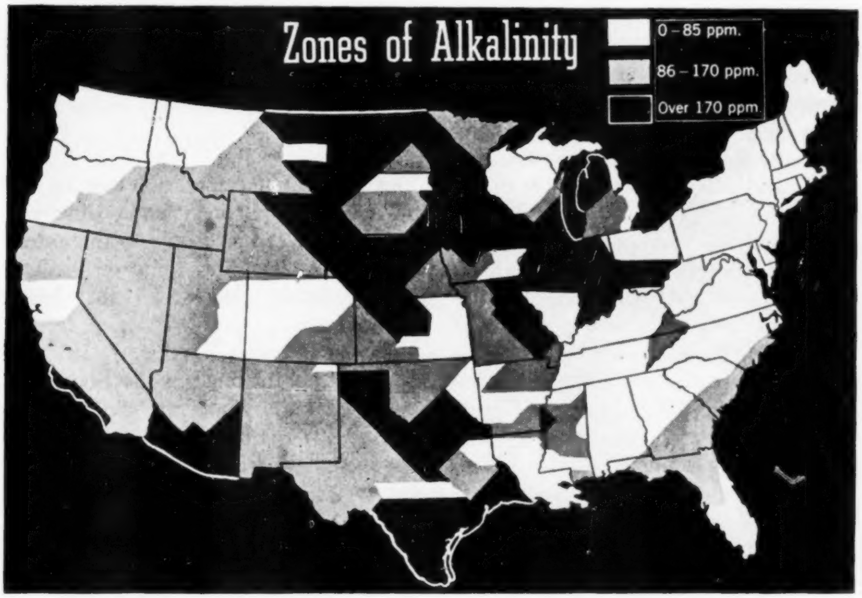


Fig. 4. Zones of Alkalinity

Whatever the location and character of the water supply, experience indicates that the individual bottling-plant operator must be assured of a continuous supply of suitable bottling water. This supply is attained by complete water treating equipment which provides for coagulation and chlorination, with alkalinity reduction by lime treatment when needed; sand filtration; and activated-carbon purification. This

equipment is employed solely for treating the water going into the product; the treatment of water for bottle washing will be discussed later.

Treatment Methods

For many years granular aluminum sulfate or lump potash alum were the principal coagulants, frequently supplemented with sodium aluminate or soda ash for pH adjustment. Dosages of 35–50 ppm. of alum were not uncommon. Also, many plants have found it necessary to maintain high chlorine residuals in connection with good coagulation in order to remove organic matter and foreign tastes completely. Residuals of 6–8 ppm. of free chlorine in the sand filter are frequently maintained.

Considerable laboratory work, confirmed by much plant operating experience, indicates that all oxidizable organic material in the water should be completely removed to avoid any possibility of flocculation or sediment formation in the finished beverage. In one plant, for example, the chlorine demand became constant at nearly 5 ppm. only when the dosage reached approximately 12 ppm. with a residual of 7 ppm. The retention time was two hours. Although the high chlorine consumption of this particular water is above average, the high chlorine dosage is typical of a number of instances when the oxidizable material in the water rose quickly, due to sharply increased runoff to a reservoir or surface supply. Under such conditions plant operators frequently find that a combination of good coagulation and adequate chlorination is needed to remove finely divided solid material effectively.

The alkaline content of many waters requires lime treatment for alkalinity reduction. Such waters also contain hardness which may interfere with efficient bottle washing. The concentration of these hardness compounds, however, is usually well below the critical point of taste effect in the beverage. The reactions given below show how the controlled addition of slaked lime and calcium chloride changes soluble alkaline material to insoluble forms:

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O$$

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + Mg(OH)_2 \downarrow + 2H_2O$$

$$2NaHCO_3 + Ca(OH)_2 \rightarrow Na_2CO_3 + CaCO_3 \downarrow + 2H_2O$$

$$Na_2CO_3 + CaCl_2 \rightarrow CaCO_3 \downarrow + 2NaCl$$

The precipitated material can be removed by settling and filtration. Hardness is reduced only to the extent that carbonates are removed, sulfate and chloride hardness not being reduced.

In the Pacific Northwest, in New England and in most of the Southeast, bottling plants would use alum coagulation with aluminum sulfate, and chlorination with filtration and activated-carbon purification, to effect complete treatment. In much of the Middle West, Southwest and parts of Florida and California, alkalinity reduction, coagulation with lump potash alum and chlorination, again with filtration and activated-carbon purification, are required for complete treatment.

The necessity for two types of treatment was objectionable but not so serious as the difficulties introduced by waters with an alkalinity generally in the neighborhood of 85 ppm. Frequently it was difficult to specify the best treating method, and the trouble was often aggravated by considerable seasonal variation in the alkaline content. In addition, continuous good coagulation was difficult to obtain in

waters containing very little alkalinity or solids and having high clarity.

The need for a single method of treatment applicable to all waters capable of being successfully treated by either of the two methods described above led to the adaptation of the ferrous sulfate–lime–chlorine treatment to bottling-plant operation. Normally, a dosage of approximately 35 ppm. of ferrous sulfate and chlorine residuals of 6–8 ppm. are employed. Lime is added as a slurry, the dosage varying, depending on the alkalinity of the water. The treatment may be represented by the equations:

$$FeSO_4 + Ca(OH)_2 \rightarrow Fe(OH)_2 + CaSO_4$$

$$4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3 \downarrow$$

$$6FeSO_4 + 3Cl_2 \rightarrow 2Fe_2(SO_4)_3 + 2FeCl_3$$

$$Fe_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Fe(OH)_3 \downarrow + 3CaSO_4$$

$$2FeCl_3 + Ca(OH)_2 \rightarrow Fe(OH)_3 \downarrow + 3CaCl_2$$

The first two equations above show the reactions between ferrous sulfate and lime at a pH of 9 or higher. Under these conditions, all of the soluble iron is removed from solution without the presence of chlorine. In practice, chlorine is always present in sufficient amount to oxidize any existing organic matter. At a pH below 9, chlorine oxidizes the ferrous sulfate to ferric sulfate, which in turn reacts with lime to form insoluble ferric hydroxide. Thus the treatment may be used to coagulate and chlorinate waters of low alkalinity. In this use, sufficient lime is added to give a pH of approximately 8.5.

In the treatment of waters whose alkalinity is above 85 ppm., sufficient lime is added to reduce the alkalinity to the desired point. The treatment is controlled by maintaining the relation: two times the phenolphthalein alkalinity minus the total alkalinity equals 0.2–0.7 phenolphthalein. If sodium carbonate is present, calcium chloride is added. Differences in alkalinity do not affect the dosages of ferrous sulfate and chlorine. The effluent is free from iron and its alkalinity is less than 35 ppm.

During the past several years dozens of new plants using this treatment have been installed and many other plants have been converted to permit its use. Thus far, the results have been excellent. Bottling-plant operators report improved water clarity and less difficulty in securing continuous good coagulation, and the treatment is much easier to control.

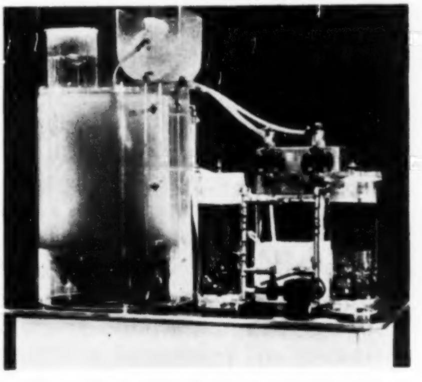


FIG. 5. Demonstration Treatment Unit

Because low-alkalinity waters can be coagulated at a high pH, the corrosion problems encountered with alum have been eliminated. The presence of vitreous phosphate in water supplies gives considerable trouble in conventional lime treatment, but it does not interfere when ferrous sulfate is used. The ferrous sulfate treatment shows promise of becoming practically a universal method.

As previously mentioned, excessive hardness may interfere with the bottle-washing operation. Precipitation in the hot, caustic washing solutions may cause cloudy bottles or scale formation on moving parts and heating coils in the bottle-washing machines. Separate treatment of the water used in washing bottles is employed to prevent the above conditions.

Bypass feeders or proportioning pumps used to introduce complex phosphates into the water have often proved successful in preventing scale or cloudy bottles. Also, many plants have installed sodium zeolite softeners to provide completely soft water for the entire bottle-washing operation.

Training Program

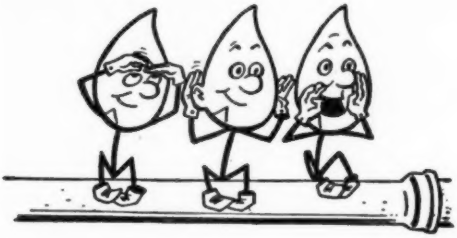
It has been found that training operating personnel and assisting them with their operating problems is of paramount importance. As in other fields, regardless of the accuracy or exactness of the methods or the efficiency of the equipment provided, in the final analysis, the quality of the results obtained depends largely upon the quality of the man who operates the equipment.

Several years ago, a broad program of training and operational assistance was begun as a part of quality control activities. This program, covering all phases of product control, places considerable emphasis on water treatment, including both the theory and the actual practical operation of the equipment. The basic features of this program include not only the company's own operating handbooks, but also formalized training programs in company schools and a traveling laboratory service.

The schools have trained many men from this country and from bottling plants all over the world in the proper methods of operating bottling-plant water treatment equipment. As an example of the emphasis placed on this subject in the production school, a demonstration unit made of clear plastic (Fig. 5) has been built. This unit, designed to deliver 0.4 gpm. with a two-hour retention time, has proved to be an exceptional teaching aid, for with it the trainee can see for himself everything that happens as he operates the equipment. The action of coagulation, the movement of slurry as it circulates, the control of sludge removal, the effect of inadequate backwash rates and the advantages of adequate rates are all forcibly demonstrated. A production handbook has been published and sent to each bottling plant. The section on water and water equipment was designed to provide all possible help to the plant operator. Many illustrations and cartoons are used in the presentation of the technical phases of water treatment.

The traveling laboratories are most helpful in rendering on-the-spot assistance with all production problems. Twenty-three of these units, with a field force of 51, are now in operation. Each unit is manned by a graduate chemist or chemical engineer and a technician. Twenty-three routes cover the entire country, and each of the laboratory units is assigned to a specific group of bottling plants. Every plant is visited regularly and a complete production survey is made during the visit. The central location of the headquarters of each unit permits great flexibility of operation, making the unit quickly available for any emergency.

The Coca-Cola Co. has been aware for many years of the water problems peculiar to the carbonated-beverage industry and is proud to say that perhaps it has, from time to time, made contributions toward solving some of the difficulties of industrial water treatment.



Percolation and Runoff

Our ballot box is bulging—and we love it. Right now (a week before the polls close and at least two weeks before the last ballot will be in) our unofficial count of votes on the restatement of the Association's objectives is a bountiful 1,673 from every state in the Union, the District of Columbia and Canada. And if our Cuban and foreign members haven't yet had time to exercise their franchise, we have an idea they will too.

What we're so jubilant about, of course, is the happy contrast between this virile vote and the feeble expression of opinion which greeted the last constitutional amendment, two short years ago. The difference between the 1947 total vote of 70 and current incomplete returns of almost 1,700 undoubtedly reflects a number of things. Certainly a clearer and more direct method of presentation had something to do with the response, but we like to think that much more significant factors were also intimately involved. Despite the virtual unanimity of opinion in both ballots, for instance, there has been a decided difference in interest in the issues at stake, which must have played a large part in attracting the current evidence of convictions. And we can at least venture the hope that the ballot barrage signalizes a more active interest in the affairs of the Association.

At the moment, however, rather than hazard further exuberant excursions into interpretation, we prefer to seek shelter in the safety of statistics. Thus, we can tender the interim information that 23.1 per cent of the 7,229 eligible voters have already gone to the polls and voiced a 98.9 per cent approval of the amended objective. Even better news is the fact that the 1,673 voters to date represent 24.1 per cent of the total eligibles in the areas from which ballots have been received and that the current leader of the poll parade is the New England Section with a 33.2 per cent say-so, closely followed by two other 30-per-centers in the Chesapeake and Kentucky-Tennessee Sections. Among the least expressive of U.S. sections thus far has been the remotest, the Pacific Northwest, but its vote had reached 18.0 per cent of eligibles by August 18 and was growing

(*Continued on page 2*)

(*Continued from page 1*)

fast. And on that date, the raw and unofficial overall picture showed 1,613 approving, 18 disapproving and 42 absent-minded (marking neither choice).

But having statisticized to that extent, we couldn't resist some further exploration, particularly with a view toward explaining why we received completed ballots from California before the ballot forms themselves reached our New York City addresses. Having deposited the entire mailing in the hands of Uncle Sam's delivery boys on July 29, we, less than ten blocks away from the point of deposit, had to wait until August 8 for it to appear in our mailbox. Meanwhile, as early as August 1, members in Nebraska, Illinois, Ohio, Georgia and even New Jersey had not only received, but read and returned their ballots. As a matter of fact, ballots from every section on the continent had been received here at headquarters before our own showed up at home. Whether this was evidence of discrimination or idiosyncrasy we haven't yet determined, but we ain't complaining, and since the returns from the local section have already reached an average 23.3 per cent, we have no real reason to.

Speaking of the mails, though, our postmark investigation revealed some interesting sidelights on the current confusion concerning postal rates. Of the 1,564 U.S. returns, only 979, a bare 62½ per cent, arrived with proper penny postage. Some 420 were three-cent stamped; 95, two-cented; 25, one-and-one-half-cented; and 46 noncented. Canadians, too, were undecided: 2 using one-cent stamps; 3, two-cent; 62, three-cent; 41, four-cent; and 1, none. What all this means, of course, is that the post office collected some extra cash. In the U.S., for instance, $9.47½ in excess postage was placed on the cards and since an extra penny was collected on each unstamped card that boosted the post office's profits an additional $0.46, making the total $9.93½. As for the Canadian total, we're so confused about the exchange situation and the Canadian postal regulations, themselves, that even we haven't been able to figure that out. Suffice it to say, however, that we're still not complaining. As a matter of fact, we're basking in ballots, sunning in statistics and generally luxuriating in the fact that the membership has spoke.

A five-man committee to interpret provisions of the recently approved plumbing code has been established by the American Society of Mechanical Engineers and the American Public Health Assn., sponsors of the code. Members of the group, which will answer inquiries about the code, are A. H. Morgan of the New York City Dept. of Public Works; C. A. Holmquist of the New York State Dept. of Health; F. M. Dawson of the University of Iowa; M. Warren Cowles, Hackensack Water Co.; and V. T. Manas of the Housing and Home Finance Agency.

(*Continued on page 4*)

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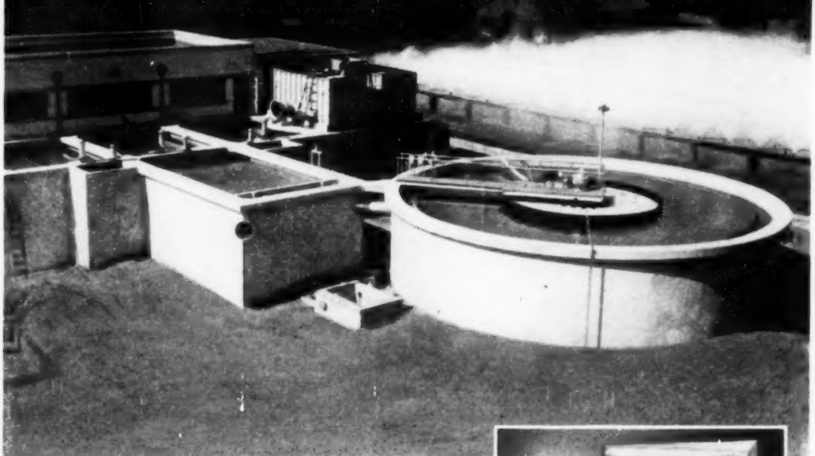

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(*Continued from page 2*)

The drought which plagued the Northeast in June and early July finally broke. By the end of July, too, the drought in Europe had substantially ended its reign, in rain. And only in Africa, where the worst drydom in more than a hundred years threatened to desiccate the entire continent, did the aridity persist. To say that this was a "bad," a "serious," a "destructive" drought is, of course, to do injustice to its record-breaking calamitousness. Just how bad it was is, as a matter of fact, impossible to describe, even in our own often custom-built words. But that it was *really* dry should be obvious from the fact that even the Atlantic Ocean was dusty.

True, the end of the drought did not bring the end of the equally record-breaking heat wave. True, too, that because of this we could not expect you to accept this information on our own possibly miragic say-so. But that the dustiness was neither imaginative nor exaggerative is attested by absolutely *official* Navy Department records, based upon a radio report from the destroyer, U.S.S. *Livermore,* which sighted "large patches of dust on the surface, stretching as far as the eye can see," and verified by the samples of "real dirt" there collected and sent to Washington for

(*Continued on page 6*)

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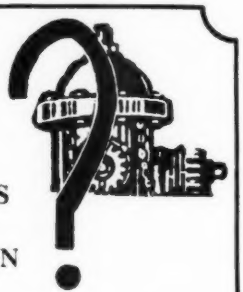

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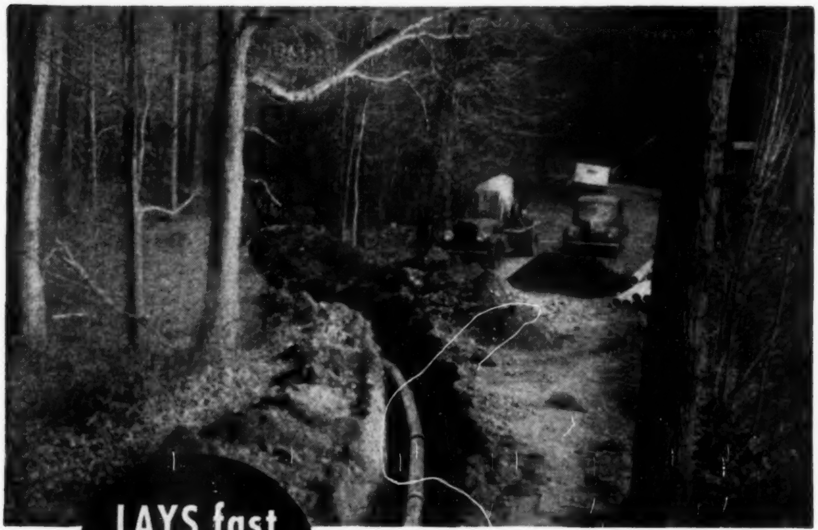

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(*Continued from page 4*)

study. Although the official Navy explanation of the phenomenon is: "unexplainable," we, who were as "dry as dust" ourselves, have little trouble understanding how something as dry as we, would naturally be attracted to water. As for the profusion of sponges also observed scattered around the surface, it appears obvious that the size of the bathtub makes little difference in one's approach to it.

At any rate, it *was* dry; and it *is* hot!

Without a drought, however, it was the people of Waynesburg, Pa., who suffered most for lack of rain, for "in Waynesburg, it always rains on July 29," and it didn't. It didn't, as a matter of fact, despite the tenacious efforts of the Borough Council in suspending Daylight Saving Time to stretch the day and in seeking precipitation throughout the broadest area of what might be a "Greater" Waynesburg; and it didn't despite the loyalty of citizens in sweltering through the sunshine in raincoats and hip boots. And since it didn't for the second successive year, the fame of Waynesburg has for all practical purposes dried up and blown away. Only the New York *Times* was kind enough to say: "Often it always rains in Waynesburg July 29," and even that, of course, was too much of a comedown to be accepted happily.

Recent hydrology was a nightmare of extremes to water works men. Drought conditions in the East forced thirsty Gasport, N.Y., to appeal for emergency diatomite filtration and chemical feeding equipment, which the Proportioneers people flew in from Providence, R.I., thus making possible the use of impounded creek water. On quite the other hand, flood conditions in Fort Worth, Tex., gave the Holly Pumping Plant an overdose of water—20 ft. of it sitting atop the electric motors which drive the centrifugal pumps—and cut off the water supply of the entire city. Jumping into the breach here was the Dallas service shop of General Electric Co., which baked the motor windings dry and also obtained a new motor in record time. With the aid of an outmoded but imperturbable reciprocating steam engine, to which floods were inconsequential, service of sorts was resumed the next day, and two days later citizens of Fort Worth were taking their baths in tubs again, rather than the streets. It's been a hectic season.

A less erratic view of hydrology is presented by C. O. Wisler and E. F. Brater, authors of the new John Wiley & Sons book on the subject. Precipitation, the unit hydrograph, average yield—and, yes, droughts and floods—are discussed and illustrated. The title, of course, is *Hydrology* and the cost, $6.

(*Continued on page 8*)

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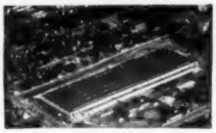

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Peerless
VERTICAL AND HORIZONTAL
Pumps

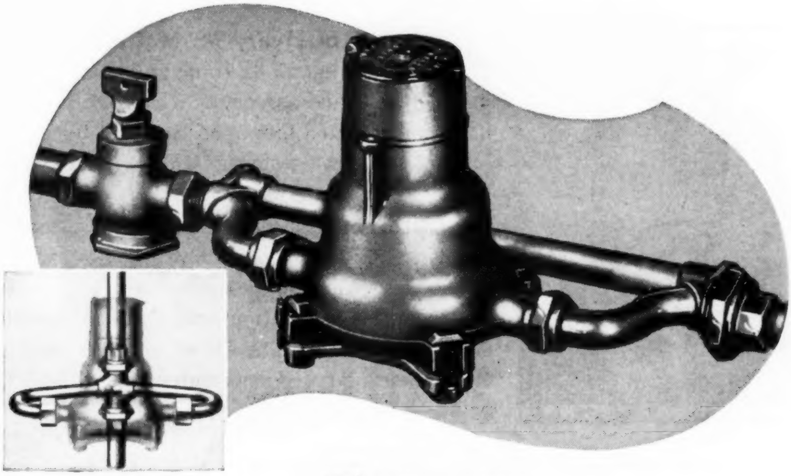
(*Continued from page 6*)

A binder for A.W.W.A. standards has been prepared, largely at the suggestion of Albert R. Davis, superintendent of the Austin, Tex., Water Department, and it is now available from A.W.W.A. headquarters. Intended for bookshelf, desk and field use, the loose-leaf binder has capacious 1½-in. rings which will hold more than a normal complement of specifications. Appearance has been subordinated to durability in the choice of sturdy blue canvas covering, with backbone lettering in a darker shade of blue, but the result is a neat and workmanlike book. Metal hinges insure maximum serviceability and protect against wear under constant use. Blank separator cards with projecting tabs are provided to permit prompt location of the user's choice of certain major groups of specifications or much-referred-to individual standards. New printings of specifications booklets have for some months been punched to fit the three rings of the binder, and all specifications will be provided in this form as soon as the older stocks are exhausted. The cost of the binder is $2.50.

A third aqueduct and three storage dams on the Mokelumne River are planned by California's East Bay Municipal Utility District in order to permit a capacity increase from 110 to 349 mgd. The addition of the three dams—one 119 ft. high, below Pardee Dam, near Clements; another 187 ft. high, above Pardee, at Middle Bar; and the third 340 ft. high, on the South Fork of the Mokelumne, near Railroad Flat—will increase the present storage facilities of 68 bil.gal. to 183 bil.gal. It is anticipated that the cost of the project will probably exceed the $39,000,000 cost of the original Mokelumne development, and that the additional capacity should suffice for an anticipated population of 2,600,000 in 30 or 40 years. The District currently serves 900,000 persons in Oakland, Berkeley, and other communities on the east side of San Francisco Bay.

A memorable speaker at the Chicago Conference was Norman F. S. Winter, Chairman of the Halifax Corp. Water Commission in Yorkshire, a member of the British Government's Central Advisory Water Committee, Past-President of the British Waterworks Assn. and currently President of the newly formed International Water Supply Assn. And his paper, which appears on p. 797 of this issue, provides a source of comment upon water supply developments—not only in Britain but with relation to those across the Atlantic—which deserves reading.

(*Continued on page 10*)



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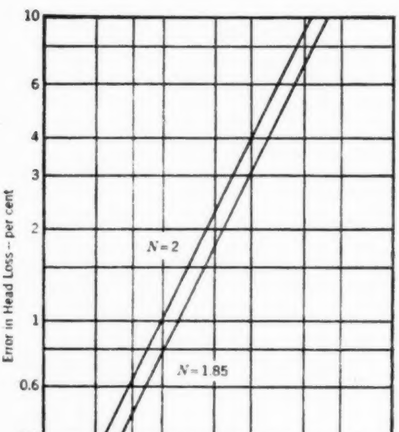
Wabash, Indiana

(*Continued from page 8*)

The death of Henry M. Mathews on August 11 at the age of 42 came as a shock to his many friends and associates who shortly before had congratulated him upon the commencement of his three-year term as A.W.W.A. Director for the Southeastern Section.

A native of Quitman, Ga., he had attended the Georgia Inst. of Technology and was a registered professional engineer in that state. He began his association with the Thomasville, Ga., Water and Light Dept. in 1926, and in 1939 was appointed superintendent, a post he held until his death.

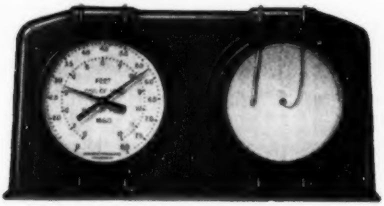
Edwin Lewis Cantrell of Louisville, Ky., died suddenly of a heart attack on July 14 at the age of 57. He had been Louisville District Manager of the Neptune Meter Co. since 1921, and had been connected with the company since 1913, with an interval of military service during World War I. He had been active in Kentucky-Tennessee Section affairs and had been chairman of its nominating committee.



A corrected copy of an illustration which contained an error when it was originally published in the JOURNAL is reproduced at the left for the convenience of those readers who wish to have their files on the subject accurate. The graph was part of Malcolm S. McIlroy's paper, "Pipeline Network Flow Analysis Using Ordinary Algebra," which appeared in the May 1949 JOURNAL (Vol. 41, p. 422). This corrected version may be cut out and pasted over Fig. 3 on p. 427, which was captioned "Error in Head Loss Approximation," and which lacks the identifying labels "$n = 2$" and "$n = 1.85$."

A formal erratum notice appears on page 796 of the text portion of this issue.

(*Continued on page 12*)



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BUILDERS PROVIDENCE
Instruments

(Continued from page 10)

The supernatural balderdash of rhabdomancy has again pierced our nonscience. Just when we thought we had given the final last word on water witch mysticism (June P&R p. 20), we encountered a new outcropping of inconclusivity.

First, in the sensational pages of the New York *Daily News,* we were given an intimate review of the twig-twitching and plier-pulling mysteries of no less than seven "water-smellers" of Lancaster County, Pa. New in this review was the revelation that a "W" in the lifeline of your hand and birth under the sign of Aquarius are virtually certain to give you the "power" of what the *Encyclopedia Britannica* calls "motor-automatism," laically attributed to the same type of inborn equipment that makes a homing pigeon come home. Then, the *Water Well Journal,* surveying the history of the divining rod, found that it could be no more conclusive than to point out that dowsers are *most* successful in areas where ample ground water supplies are available at any dig. And the final note in the series, appearing in the June issue of *The Driller,* too, was conclusive only on a strictly personal plane, for the well driller there described, who insisted on hiring a dowsing friend to locate a new well area, did strike water only 15 ft. down. What piqued him, of course, was that the water was in a sewage pipe, which also poured forth a friend-ending ooze of filth and corruption.

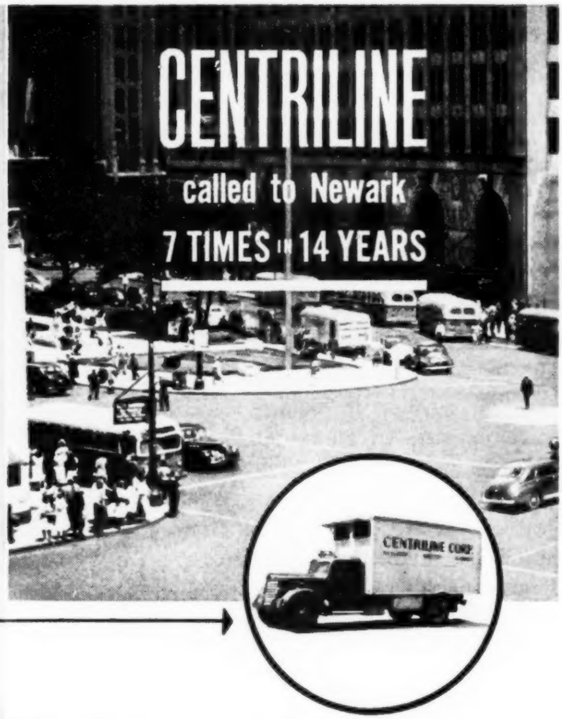
If nothing in the above reviews seems to justify the characterization "balderdash," we will admit that we're tired of timidity and, too, that our consequent espousal of science will leave us almost as completely in the dark concerning the actual intricacies involved in finding water. But at least radar, geology, even meteorology, can be explained in words, which, regardless of our ability to understand, gives us comfort and a sense of well-being. Thus, from doubting, we've turned to routing dowsing and have climbed aboard at least this one tongue of the science bandwagon.

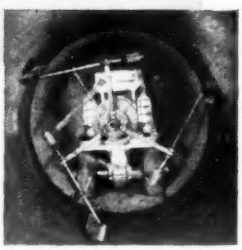
Top tap team in this year's water main tapping contest at the July 14 meeting of the Westchester Water Works Conference was the twosome representing the local Greenburgh, N.Y., Water Department. Making a ¾-in. tap on a main under pressure at an unprepared site designated by the judges, the home team completed its job in less than seven minutes to carry off the Kassay Cup for the coming year. And what's your time on the job?

William E. Holy, sanitary engineer, has been assigned to the Division of Sanitation of the U.S. Public Health Service at Washington, D.C., to handle water works matters. He had previously been manager of the West Virginia Water Service Co., Oak Hill, W.Va.; and, more recently, had been in Peru with the Oficina Sanitaria Pan American.

(Continued on page 14)

where performance counts . . . count on Centriline





IN 1935 Centriline did its first work for the city of Newark, N. J.—cleaned and lined with cement mortar 27,551 feet of 48" riveted steel pipe. The capacity of this 40-year old pipe was thereby increased 77%—*12% higher than the original capacity—and it has stayed there!*

That may explain why Centriline has been called back again and again to recondition more of Newark's vital water mains. To date, more than 40 miles of these mains have been Centrilined.

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(*Continued from page 12*)

The peaceable applications of atomic research are either virtually nonexistent or poorly publicized. We've heard of course of the wonders of isotopes, but they, we understand, are by-products and we're interested in the real thing. We admit, of course, that we were a little cheered the other day when we heard that the Argonne National Laboratory had been able to radioactivate algae for use as tracers in studying animal metabolism, but that too seemed a singularly undramatic contribution. And what little cheer it did bring was dissipated in a confused cloud of suspicion at the news that two Army medics had similarly radioactivated mosquitos so that their flight and attack habits could be studied. As a matter of fact, they might better have directed their attention at the effectiveness of screens or citronella as an anti-Air Force measure.

No, what we're looking for is some dramatic dividend from our tax-took billions—a regional atomic air-conditioning system, perhaps, to keep us comfortably cool in summer and warm in winter; definitely an atomic supplement to our own energies so that we can spare our own for the enjoyment of a greater freedom from drudgery; and, at the very least, an atomic robot to fight our future wars upon some remote planet, thus to obviate our own embroilment and to conserve our resources for constructive ends. To date, at least, splitting the atom has resulted in too many pieces and too little peace.

To war research, we must of course give some credit. Through wartime radar we can now spot a rainstorm a hundred miles away and keep an eye on it until it actually strikes home. Although that's not nearly as good as pushing one away when we don't want it and attracting or even creating one when we do, it is really no mean accomplishment at that.

Studies of the application of radar to forecasting precipitation and runoff made by the Illinois State Water Survey Division,* for instance,

* Stout, G. E. & Huff, F. A. *Radar and Rainfall.* Report of Investigation No. 3, State Water Survey Div., Urbana, Ill. (1949).

(*Continued on page 16*)

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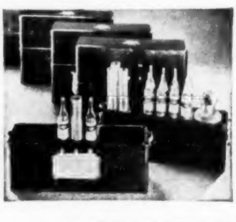

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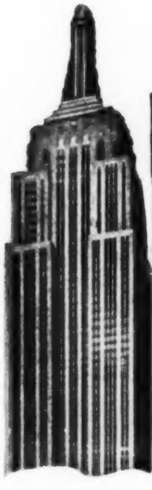

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New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.

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2. Frangible couplings for collision protection.
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ESTABLISHED 1896
EAST ORANGE, NEW JERSEY

(*Continued from page 14*)

have indicated the possibility of economic values in providing accurate warnings of the occurrence and severity of storms. And installations such as the recent one made by the New York City Weather Bureau promise more accurate forecasting.

Having mentioned the "creation" of storms, however, we must not fail to point out that the Illinois weather studies included a series of rainmaking experiments which proved that cloud seeding was effective under certain atmospheric conditions and was advantageous both in speeding up the precipitation process to make rain fall where it was most needed and in inducing precipitation from clouds which would eventually dissipate without releasing their moisture. Admitting that the dry-ice and other techniques would be of diminished value during drought conditions, the survey group leaned toward acceptance of Dr. Irving P. Krick's conclusions that rainmaking could be economically justified in preference to the contrary opinion voiced by the Air Force following its unsuccessful Ohio experiments in 1948.

And if this discussion doesn't prove that war research is easily forgotten, it should at least indicate that weather is changeable.

The cause of employee inefficiency and absenteeism has at last been satisfactorily explained—satisfactorily, that is, as far as we are concerned. Advertising its patented water cooler under a banner headline of "Drink More Water," the Canaday Cooler Co. of New York cites the opinion of "prominent health authorities" as agreeing that thousands of workers are literally "water starved," and thus listless, inefficient and less resistant to disease. Indicating that the cause of such starvation is the remoteness or unpalatability of the drinking water supply on the business premises, Canaday offers its cooler as a practically foolproof focus of business success.

Were we less sympathetic toward the appeal itself, we might wish to balance the ambulatory loss against the efficiency gain, perhaps even to compare the effects of water logging with water starving, but who are we to be unkind to a water booster? If we have any criticism at all, it is with Canaday's oversight of the personnel morale angle, for the social significance of the water cooler appears to us to be one of its outstanding characteristics.

Our own, possibly biased, appreciation of Canaday's high valuation of the water cooler is, however, not the best proof of its acceptance. More convincing by far is the report from Beaver Falls, Pa., that the only loot in a recent burglary of its city hall was the mayor's water cooler. Whatever the political implications of the theft, there is no questioning the fact that if a thief will risk the cooler for a cooler, it must have more than the material value we ordinarily ascribe to it.

(*Continued on page 18*)

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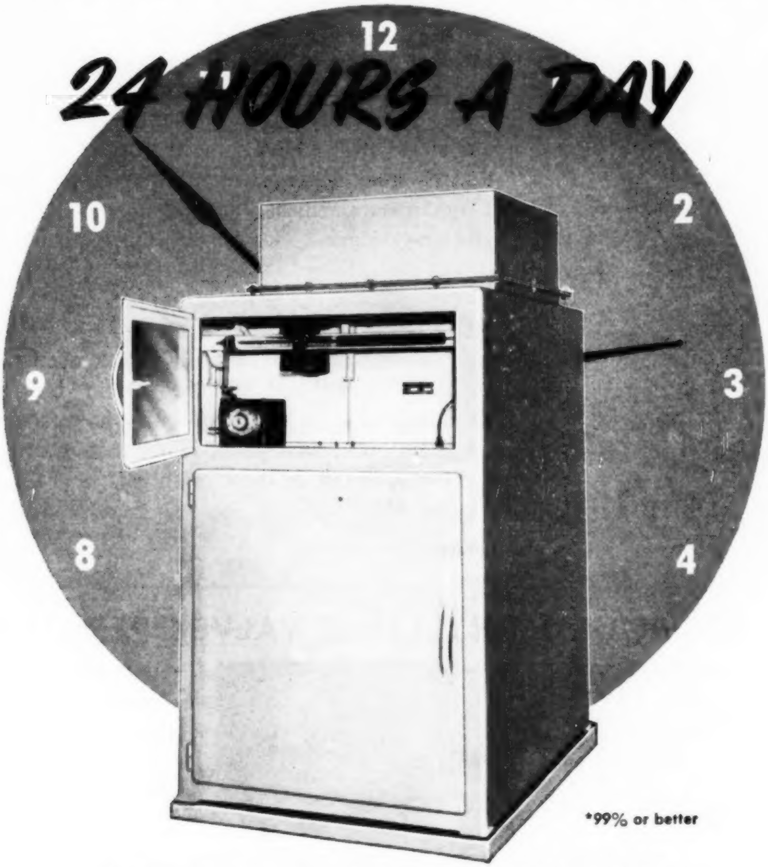

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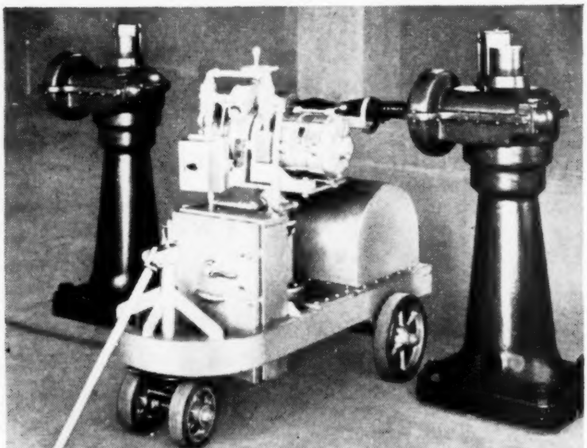
(Continued from page 16)

The Southwest Section has established a Membership Cup which will be presented—for the first time at the Oklahoma City meeting October 9–12—to whichever state in the section attains the greatest weighted membership gain. The formula for computing gains is similar to that used for the national Hill Cup award, and depends upon a quota system based upon the urban population of the four states—Arkansas, Louisiana, Oklahoma and Texas.

The effect the cup will have may perhaps best be measured in terms of the relative standings of the Southwest and New York Sections, currently jockeying for the second highest membership in A.W.W.A., with 652 and 655 members respectively (August 1st count). California is out in front, with 810; and Canada (with 510) and Illinois (with 453) complete the "big five."

(Continued on page 20)

LIMITORQUE "*PORTABLE*" VALVE OPERATOR



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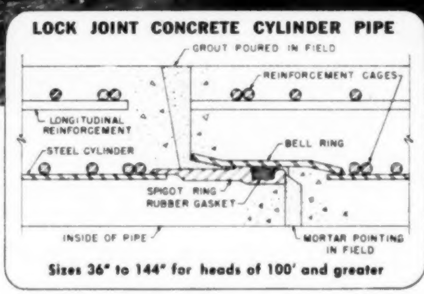

A section of 78" Lock Joint Concrete Cylinder Pipe being installed in Unit 1 of the Coachella Valley Distribution System, a U. S. Bureau of Reclamation Project, comprising some 37,000' of 78" and 84" Lock Joint Concrete Pressure Pipe.

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Performance in this important water supply line is the result of multiple requirements: (1) great strength, both for resistance to design operating pressures and for great earth loadings—all with an ample factor of safety; (2) flexible, yet positively watertight joints; (3) resistance to corrosion and tuberculation which assure maximum and sustained hydraulic capacity. This superior design of pressure pipe combines the physical properties of steel with the structural and protective properties of concrete to meet the most exacting job requirements, and the Lock Joint Rubber Gasket Joint provides ease of installation, flexibility and trouble-free service under all normal operating conditions.

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(*Continued from page 18*)

Another pound of cure that will be greeted by water works ounce of preventionists is bacitracin, the new antibiotic, which has been found effective in the treatment of amebic dysentery. One of the big five "wonder drugs" now in mass production—the others are penicillin, streptomycin, aureomycin and chloromycetin—bacitracin has an 86 per cent score of successes in its battles against the protozoan, *Endamoeba histolytica,* and promises to be a valuable weapon against the numerous tropical diseases for which there is now no cure. Effective also in shortening the duration of head colds by attacking the germs which trail along with the causative virus and in treating various skin infections, infected wounds and conjunctivitis, the new drug, like other members of its mold-made family, is practically a panacea.

What further waterborne diseases will be found to yield to these and to other antibiotics such as neomycin, polymixin, aerosporin, mycomycin and borrelidin, now in the experimental stage, it is difficult to predict, but there is little question that progress in the field of curing disease has been more dramatic than that in the field of preventing it. And quite apart from every ounce of effort put forth in the field of sanitary engineering and public health, the conquest of such scourges as Rocky Mountain spotted fever, deadly types of pneumonia, undulant fever and scrub typhus are major contributions which advance the hope that we will one day even be able to combat, if not to understand, the viruses.

The head-loss problem came to roost in Roseland, N.J., last month and taxed the worrying capacity of the Borough Council for a few anxious days. The head actually belonged to one Raymond Sigler, the borough's water system inspector, and the loss involved his departure on a six-month leave of absence. What bothered the council was that, after granting Sigler his leave, they found that the only accurate map of the water system reposed in his memory. Thus, with Sigler virtually on his train, the proper indoctrination of a substitute was patently impossible. Only the appearance of another memory man saved the day—that day, that is, but we venture a guess that at least part of his job is already mapped out for him.

Warm tribute was paid by his townsmen recently to R. B. Simms, superintendent of the Spartanburg, S.C., water works since 1920. In recognition of his handling of the growth of the system in that time from a production of slightly over 1 mgd. to more than 8 mgd. without a single case of sickness traceable to water or a shortage during even the severest drought season, the city's Commissioners of Public Works proclaimed that the name of the South Pacolet Filter Plant would be changed to the R. B. Simms Filter Plant.

(*Continued on page 70*)

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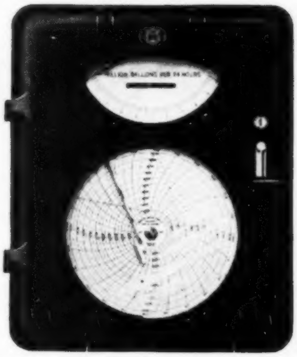

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HARCO CORPORATION

Correspondence

Yes . . . and No

To the Editor:

Re: Cover picture vs. contents [August JOURNAL, p. 36]—my vote goes to pictures. In my opinion, technical journals such as this need pictures—not only on the cover but inside as well. In the August 1949 issue there are no photos and only one drawing between pages 675 and 770.

LLOYD K. CLARK

1103 W. Pratt St.
Baltimore 23, Md.; Aug. 16, 1949

To the ***Editor:***

Now that you ask for an expression of opinion, I will say what I have been thinking, which is in support of Messrs. Weir, Aldrich and Riley. The JOURNAL looked far more business-like and professional with the main contents listed on the cover. This also made it far more easy to locate articles when need arose. Like Weir, I would vote for larger type for volume number and issue date on the backbone.

Going back to the "contented" cover as you describe it is going to give you a cover redesign problem—I can see that.

L. H. ENSLOW

Vice Pres. & Editor
Water and Sewage Works
155 E. 44th St.
New York 17, N. Y.; Aug. 17, 1949

Après these, le deluge—we hope. For now, we're right back where we started, with the score 3–3 instead of 2–2. Anyway, friend Clark's second comment is answered in this issue. —ED.

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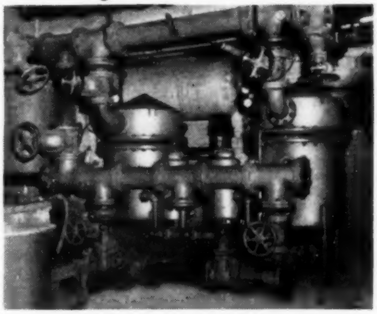

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Membership Changes

NEW MEMBERS

Applications received July 1 to 31, 1949

Activated Alum Sales Corp., M. E. Shoemaker, Secy., 516 N. Charles St., Baltimore 1, Md. (Assoc. M. July '49)

Budrick, Robert J., Chemist, Sewage Disposal Plant, 205 Lathrop Ave., Boonton, N.J. (July '49)

Camas, City of, Munic. Water Utility, Camas, Wash. (Corp. M. July '49)

Campbell, William V., Sales Engr., A. P. Smith Mfg. Co., Flandreau, S.D. (July '49)

Crook, W., *see* Eastern Irrigation Dist.

Davis, Justin J., Chief Distr. Engr., Hydr. Eng. Dept., Light, Gas & Water Div., 179 Madison Ave., Box 388, Memphis, Tenn. (July '49)

Dice, Owen, Sr. San. Chemist, Dept. of Water Supply, 8300 W. Warren, Dearborn, Mich. (July '49)

Druley, James E., Water Engr., El Paso Natural Gas Co., Bassett Tower, El Paso, Tex. (July '49)

Eastern Irrigation Dist., W. Crook, Chief Engr., Brooks, Alta. (Corp. M. July '49) *MPR*

Etchison, Gibson O., *see* West Point Mfg. Co.

Feldman, Edward, Mgr., Washington Water Co., 24 Belvidere Ave., Washington, N.J. (July '49)

Finke, R. W., City Engr., 404 County-City Bldg., Seattle 4, Wash. (July '49)

Finn, William P., Vice-Pres., Dan's Machine Works, 3319 E. Slauson Ave., Los Angeles 11, Calif. (July '49) *MR*

Ginsbury, William, Mech. Engr., Water Div., Ontario, Calif. (July '49) *MPR*

Griffith, Emmett, Utility Foreman, Maumelle Ordnance Works, Route 3, Vilonia, Ark. (July '49) *MP*

Gunter, L. P., Jr., Water Works Operator, Water Works, 507 S. 3rd St., Sanford, N.C. (Jan. '49)

Harris, Percy F., Supt., Water Dept., School St., Decatur, Mich. (July '49) *M*

Houser, Paul J., Director, Div. of Public Health Eng., State Dept. of Health, Des Moines 19, Iowa (July '49) *P*

Johns, Fred C., Engr., Dan's Machine Works, 3319 E. Slauson Ave., Los Angeles 11, Calif. (July '49) *MR*

Jones, J. Mack, Cons. Engr., J. H. Flood & Co., 13–14 Mays Bldg., Corsicana, Tex. (July '49) *MPR*

Jonsson, J., *see* Prince Albert, City of

Kochtitzky, Oscar Wilbur, Jr., San. Engr., Public Health Eng. Branch, Tennessee Valley Authority, Knoxville, Tenn. (July '49) *P*

Lamoureux, Marcel, Cons. Engr., 6305 Louis Hemon, Montreal, Que. (July '49)

Lardieri, Nicholas John, Graduate Student, Civ. Eng., Purdue Univ., West Lafayette, Ind. (Jr. M. July '49)

Lewes, Town of, C. C. Marshall, Secy., Board of Public Works, 2nd & Market Sts., Lewes, Del. (Corp. M. July '49)

Long, Wilbur Eugene, Jr., Supt., Water Plant, Public Works Com., Fayetteville, N.C. (July '49) *P*

Lortz, Charles E., Water Supt., Water Dept., 209 W. Franklin Ave., El Segundo, Calif. (July '49)

Ludwig, Russell G., San. Engr., Ludwig Bros., Engrs., 608 S. Fair Oaks Ave., Pasadena, Calif. (July '49) *MP*

Marshall, C. C., *see* Lewes, Town of

Martin, Robert Emmett, Cons. Engr., J. Stephen Watkins & Robert E. Martin, Cons. Engrs., 210 Heyburn Bldg., Louisville, Ky. (July '49) *P*

Maurer, E. H., Utilities Engr., City Bldg., Sidney, Ohio (July '49)

Milewski, Anthony Lloyd, Mgr., Water Filtration & Supply, Grossinger Hotel, Ferndale, N.Y. (July '49) *MPR*

(Continued on page 30)

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Nelson, H. Lloyd, *see* Pontusco Corp.

Newman, F. H., Supervisor of Water Treatment, Utilities Com., 3665 Wyandotte St., E., Windsor, Ont. (July '49)

Parton, Cauley Alvin, Chief Operator, Filter Plant, Water & Light Com., Greeneville, Tenn. (July '49) *PR*

Pentecost, Francis C., Asst. Distr. Engr., Hydr. Eng. Dept., Light, Gas & Water Div., 179 Madison Ave., Box 388, Memphis, Tenn. (July '49)

Pontusco Corp., H. Lloyd Nelson, Pres., Burlington, N.J. (Assoc. M. July '49)

Prince Albert, City of, J. Jonsson, Supt. of Utilities, Prince Albert, Sask. (Corp. M. July '49)

Rizi, Robert P., Inspector, Dist. of Columbia Health Dept., Bureau of Public Health Eng., Washington, D.C. (July '49) *MP*

Schaeffer, John Joseph, Jr. Engr., c/o Underwood & McLellan, Flin Flon, Man. (July '49) *MPR*

Sharpe, K. H., Engr., Provincial Dept. of Health, 807 Richmond St., W., Toronto, Ont. (July '49)

Shelton, M. J., Gen. Mgr. & Chief Engr., La Mesa, Lemon Grove & Spring Valley Irrigation Dist., La Mesa, Calif. (July '48)

Shoemaker, M. E., *see* Activated Alum Sales Corp.

Somers, Donald McLean, San. Engr., Creole Petroleum Corp., Medical Dept., Judibaha Office, Las Piedras, Estado Falcon, Venezuela (July '49)

Stein, Fred C., Jr., Div. Engr., New York City Dept. of Water Supply, Gas & Elec., Box 908, Kingston, N.Y. (July '49) *MPR*

Stewart, Austin Bell, Asst. Mgr., Sewerage & Water Works Com., Box 31, Hopkinsville, Ky. (July '49) *M*

Strickland, Raymond E., Jr., Partner, Strickland & Schroeder, Engrs. & Consultants, 2129—7th Ave., N., Birmingham, Ala. (July '49) *MPR*

(*Continued on page 32*)

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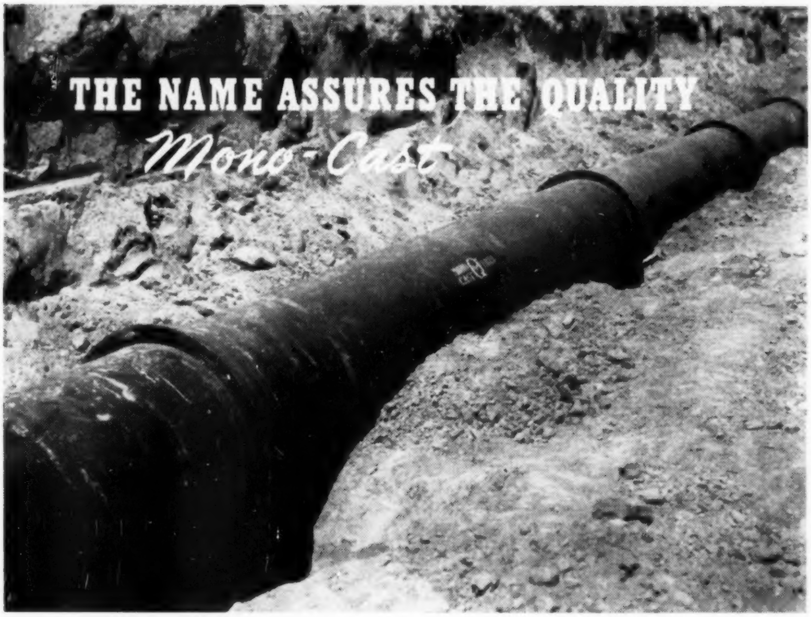

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Virginia Hot Springs, Inc., Carl J. Wallin, Chief Engr., Hot Springs, Va. (Corp. M. July '49)

Wallin, Carl J., *see* Virginia Hot Springs, Inc.

West Point Mfg. Co., Research Div., Gibson O. Etchison, Chem. Engr., Chem. Dept., Shawmut, Ala. (Corp. M. July '49) *MP*

Wheeler, Frank W., Prof. of Civ. Eng., Univ. of Virginia, Box 1214 University Station, Charlottesville, Va. (July '49)

Winter, Carl W., Supt., New Miami Water Works, 60 Miami St., New Miami, Hamilton, Ohio (July '49)

Winter, Henry Lisle, Water Supt., Water Dept., City Hall, Redwood City, Calif. (July '49) *M*

REINSTATEMENTS

Clarkson, L. M., Director, Public Health Eng., State Dept. of Health, State Office Bldg., Atlanta 3, Ga. (Aug. '29) *P*

Rice, Hugh B., City Mgr., Box 145, Williamsburg, Va. (June '34)

Townsend, Charles P., Supt., Public Works Com., Laurens, S.C. (July '35)

LOSSES

Deaths

Gaspard, August, Supervisor of Plumbing, Sewerage & Water Board, 526 Carondelet St., New Orleans 12, La. (July '37)

Hollinsworth, Morris F., Mgr., Light & Water Dept., Lafayette, Ala. (Apr. '43)

Mort, Linwood G., Partner, Argraves & Mort, Cons. Engrs., 70 College St., New Haven, Conn. (Apr. '46) *PR*

Olson, H. M., Cons. Maintenance Engr., Morton Salt Co., 120 LaSalle St., Chicago 3, Ill. (Jan. '49)

Stewart, F. D., Asst. Chief Engr., State Dept. of Health, State Office Bldg., Columbus, Ohio (July '44) *PR*

Resignations

Hinmon, Don L., Mgr., Transite Pipe Dept., Johns-Manville Sales Corp., 816 W. 5th St., Los Angeles, Calif. (Jan. '46)

Martindale, R. W., 275—14th Ave., San Francisco 18, Calif. (Nov. '23)

Sousa, Philip J., Comr. of Public Works, Water Dept., City Hall, Santa Cruz, Calif. (Oct. '43)

U.S. Electrical Motors, Inc., F. O. Luenberger, Chief Design Engr., 200 Slauson Ave., Los Angeles 54, Calif. (Assoc. M. Jan. '48)

Wills, Irvin A., Bacteriologist, John Brown Univ. & City of Siloam Springs, Siloam Springs, Ark. (July '46)

CHANGES IN ADDRESS

Changes received between July 5 and August 5, 1949

Ault, Bruce A., 3900 Collis Ave., Los Angeles 32, Calif. (July '46) *P*

Benoit, Jacques E., c/o H. W. Lea, Cons. Engr., 1226 University St., Montreal 2, Que. (Jan. '47) *P*

Berens, Richard Conrad, Research Asst., Pennsylvania Economy League, 611 Blackstone Bldg., Harrisburg, Pa. (Apr. '49) *M*

Bickel, W. E., Mgr., Empire Pump & Process Co., Box 33, Riverton, Wyo. (July '46)

Bovard, Paul F., California Filter Co., 960 Folsom St., San Francisco 7, Calif. (Aug. '26) *P*

Carnahan, R. D., 21—3rd St., S., St. Charles, Ill. (Jan. '47)

Clark, Owen E., Lock Joint Pipe Co., Box 175, Ciudad Trujillo, Dominican Republic (Oct. '38) *P*

Cosens, Kenneth W., Dept. of Civ. Eng., Ohio State Univ., Columbus 10, Ohio (Oct. '47) *PR*

Cutler, Ralph W., Southwest Welding & Mfg. Co., Alhambra, Calif. (Jan. '41) *M*

Drager, W. C., Village Mgr., Kenilworth, Ill. (July '47)

Ediger, Olin O., The Ediger Eng. Co., 252 Laura, Wichita, Kan. (Jan. '47) *PR*

Farrington, Floyd G., Service Engr., Infilco, Inc., Box 12, Christoval, Tex. (July '48)

Fenton, M. F., 258—20th St., Santa Monica, Calif. (Dec. '32)

Ferem, Walter, Pres. & Gen. Mgr., The Walter Ferem Co., 2700 W. 3rd St., Los Angeles 5, Calif. (Jan. '40)

(Continued on page 34)

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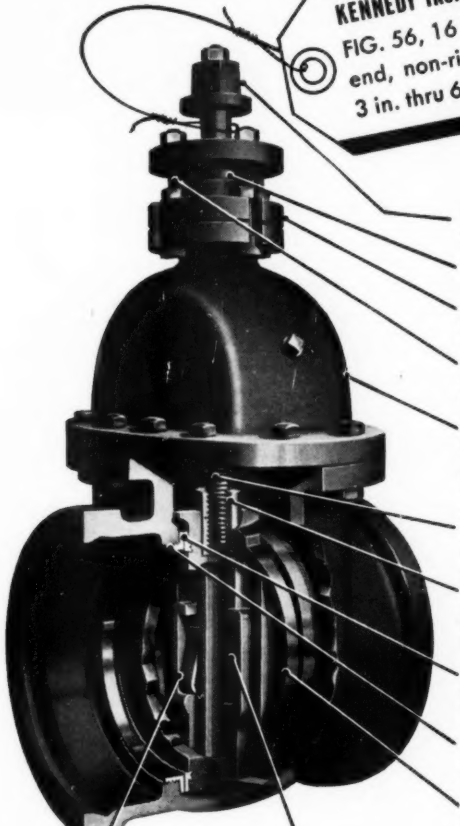

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(*Continued from page 32*)

Forbes, H. de B., Jr., Lt. Col., 1st Co. Tech. Squadron, Forbes Air Force Base, Topeka, Kan. (Jan. '46)

Gold, Donald Davis, Asst. Research Engr., Eng. Expt. Station, Univ. of Tennessee, Knoxville, Tenn. (Jan. '43)

Grieve, Robert M., Supt., Citizens Water Supply of Great Neck, 175 W. Shore Rd., Great Neck, N.Y. (Apr. '47) *P*

Gruetzmacher, Clarence Saylor, Professional Engr., R.R. 4, Box 58, Sunset Hill Rd., Corvallis, Ore. (June '20) *MPR*

Hamilton, Richard L., Sales Engr., Pittsburgh Equitable Meter Div., Rockwell Mfg. Co., 1706 Howard St., Jackson, Miss. (July '47) *M*

Heiss, Edward A., Director, Food Div., Wallace & Tiernan Co., Inc., Monrovia, Calif. (Oct. '42) *MP*

Hermann, Joseph T., Supt., Water Works, Town of Lake, 1843 E. Eden Pl., Milwaukee, Wis. (Apr. '49) *MP*

Heyward, Nathaniel J., 4202 Elsrode Ave., Baltimore 14, Md. (July '45) *P*

Holy, William E., San. Engr., Div. of Sanitation, U.S. Public Health Service, Washington, D.C. (July '34)

Jenkins, Joe E., 2111 National Standard Bldg., Houston 2, Tex. (July '42)

Jensen, Axel, Operating Engr., Riverdale, N.D. (Apr. '43) *MP*

Jodaitis, Ladislaus T., Federal Security Agency, 120 Boylston St., Boston 16, Mass. (July '43) *P*

Kaufman, Warren J., 1151 E. 17th St., San Bernardino, Calif. (July '47) *MP*

Klein, Howard S., Geologist, U.S. Geological Survey, 301 Porbeck Bldg., 515 E. 2nd St., Little Rock, Ark. (Oct. '48)

Knight, H. R., 2124 Kimball Terrace, Norfolk 12, Va. (Jan. '48)

McKee, J. E., Prof., Civ. Eng. Dept., California Inst. of Technology, Pasadena 4, Calif. (Jan. '43) *MPR*

Mizwicki, Sigmond Benny, 8340 Kingston Ave., Chicago 17, Ill. (July '45) *P*

Nix, Lewis E., Mgr., Schulenburg, Tex. (Oct. '43)

Polk, Wesley W., Chief Highway Engr., 2100 Willemoore Ave., Springfield, Ill. (Mar. '26) *M*

Ramsey, Elizabeth B. (Mrs.), 556 Belvidere Ave., Plainfield, N.J. (Jan. '41) *P*

Reed, Ralph, 215—5th St., S.W., Watertown, S.D. (Jan. '47)

Risquez C., Alfonso A., Urbanizacion Washington, Avenida Bolivar, Quinta Antillana, El Paraiso, Caracas, Venezuela (Jr. M. Apr. '49)

Ritchie, Richard J., 46-02—5th St., Long Island City, N.Y. (Jan. '43) *P*

Robeck, Charles, Contractor-Sales Mgr., Robeck Construction Co., 610 Standard Oil Bldg., Omaha 2, Neb. (Apr. '47)

Salvato, Joseph A., Jr., Erie County Dept. of Health, 605 City Hall, Buffalo, N.Y. (Jan. '47)

Schindler, Richard R., 8102 W. Norton Ave., Los Angeles 46, Calif. (Jan. '49)

Shillinger, William D., 205 Harrison St., LaPorte, Ind. (Oct. '44) *MPR*

Spieker, Roy G., 721 S. 1st Ave., Sioux Falls, S.D. (Jan. '47) *P*

Suryaprakasam, M. V., c/o C. D. Spangler, U.S. Public Health Service, Training Div., Columbus, Ga. (July '49)

Taylor, Floyd B., San. Engr., U.S. Public Health Service, 42 Broadway, New York, N.Y. (July '39)

Tibbett, William M., 116 W. Temple St., Los Angeles 12, Calif. (Oct. '43) *P*

Walling, Ernest, Engr., Water Works, 5 Clark St., W., Leamington, Ont. (Jan. '46) *MPR*

Ward, Sam B., 828 Yellowstone Ave., Billings, Mont. (Apr. '48)

Whitley, F. H., Lt. Col., MSC, Medical Sec., Headquarters 8th Army, APO 343, c/o Postmaster, San Francisco, Calif. (Jan. '39) *P*

Wieters, A. H., U.S. Public Health Service, Div. of Water Pollution Control, Washington 25, D.C. (Nov. '21) *PR*

Zadigan, Ruben, Chemist, National Brewers' Academy, 220 E. 23rd St., New York, N.Y. (Oct. '42)

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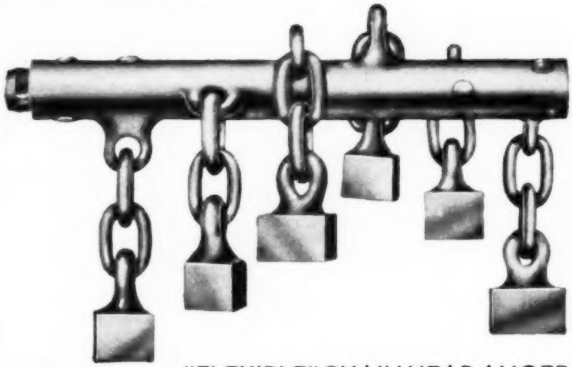

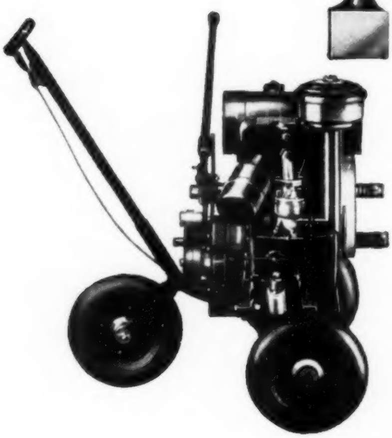

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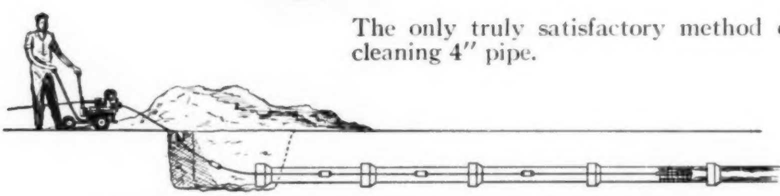

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Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issued dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (Great Britain).*

CHEMICAL ANALYSIS

Determination of Inorganic and Protein Ammonia in Drinking Water. S. K. CHIRKOV. J. Applied Chem. (U.S.S.R.), **19**: 601 ('46). NH_2 detd. by distn. in presence of ZnO, while protein NH_2 detd. by distn. in presence of CaO and $KMnO_4$ soln. Nessler reagent used for detn.—*P.H.E.A.*

Determination of Small Quantities of Arsenic in Water. V. I. ADAMOVICH & A. I. RYBNIKOVA. Savodskaya Lab. (U.S.S.R.), **13**:487 ('47). To 300–500 ml. water contg. various amts. of As add 10% soln. of ammonium iron alum and ammonia to smell; shake, heat to boiling and filter off iron hydroxide ppt. contg. As. Dissolve in hot HCl (1.10); vol. should not exceed 5–7 ml. and As content 0.01–0.08 mg. Add 1–2 ml. of 1% $CuSO_4$ soln. in HCl (1.10) and 5 ml. HCl soln. of Na hypophosphite. Keep soln. and stds. on boiling water bath for 30 min. Then compare soln. with stds. Stds. prepd. with 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08% As, 2–3 drops of 10% soln. of iron oxide in HCl, 1–2 drops of 1% $CuSO_4$ soln. in HCl, 5 ml. Na hypophosphite, and enough HCl (1.10) to give same vol. as test soln. As can also be removed with MnO_2, but single extraction did not remove all As. Sensitivity of method is 0.01 mg. in sample.—*C.A.*

New Graphic Representation of Carbon Dioxide—Carbonates Equilibrium in Water. J. HALLOPEAU. Tech. Sanit. (Fr.), **44**:1 (Jan.–Feb. '49). General definitions, discussion of physical equil. of CO_2 in soln., chem. equil. of carbonates, neutralization of CO_2, pH equil., pH of satn. as index of satn., different forms and functions of CO_2, graphical presentation of equil. and its applications.—*W. Rudolfs.*

The Theoretical Basis for the Determination and Calculation of Aggressive Carbon Dioxide in Natural Waters. H. SCHMASSMANN. Schweiz. Arch. Angew. Wiss. u. Tech. (Swiss). **13**:9:275 (Sept. '47). After short introduction author discusses lime-carbon dioxide equil. (soly. product of calcium carbonate; first and second dissociation consts. of carbonic acid; effect of salts on lime–carbon dioxide equil.) and aggressive carbon dioxide; hydrogen ion concn. of natural waters. 14 refs. Nomograms for detn. of pH and "free nonaggressive" carbon dioxide.—*Corr.*

New Method of Chlorine Determination in Water. T. I. GOLUBEV. Gigiena i Sanit. (U.S.S.R.), **12**:10:27 ('47). Specific and sensitive reagent for free Cl_2 is tris (*p*-dimethylaminophenyl)methane-tri-HCl which gives violet color (Crystal violet) with trace of free Cl_2, color d. being proportional to Cl_2 concn. Reagent used in 1% HCl, 2 drops (0.03 ml.) for 200 ml. test water; color matching done after 3–5 min. standing. At 0.1–0.25 mg./l. of Cl_2 in water, color weakly violet; at 0.3–0.4, violet; and 0.5–0.6 mg./l. gives deep violet color. Comparison can be made in std. visual color tubes.

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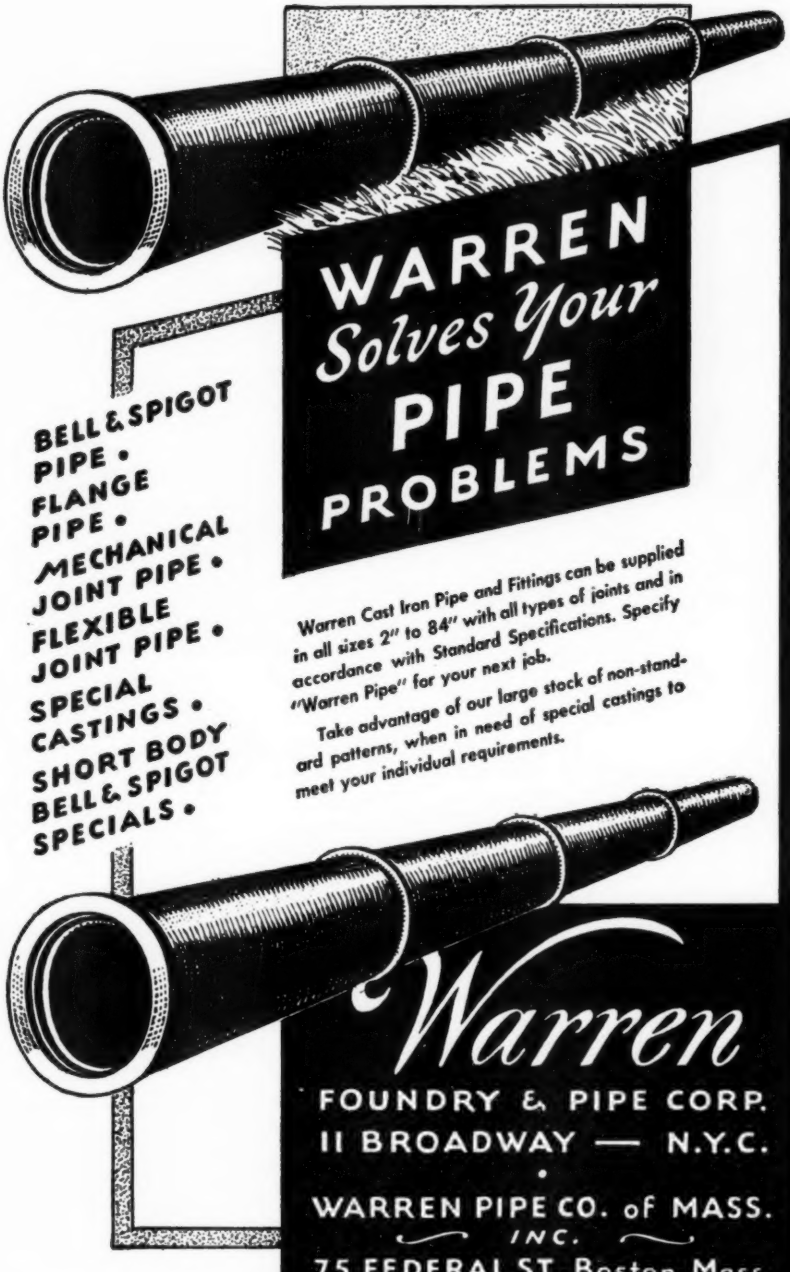
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(*Continued from page 36*)

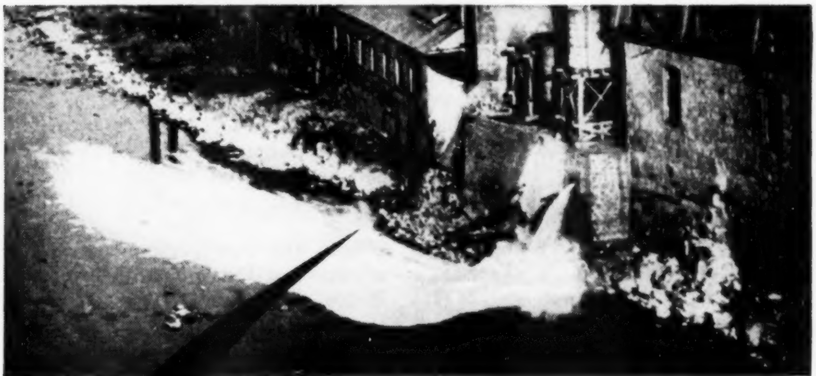
Color also developed with chloramines but require prelim. boiling for 5 min., which permits separation.—*C.A.*

The Influence of Small Quantities of Sulfur and Cyan Compounds on the Velocity of Oxidation of Ferro Ions to Ferric Ions. W. KAUFMANN. Water (Neth.), **32**:217 (Nov. 11, '48). Minute quants. of H_2S, thiosulfate, colloidal S, cyanide, ferro cyanide, ferric cyanide, cystine and glutathion retard oxidation by oxygen of ferro ion to ferric ion in water. Amts. up to 1 ppm. sulfite had practically no effect, but amts. of 30 ppm. accelerated oxidation veloc.; sulfanilamide, sulfathiazol and sulfate had no effect. Retardation caused by sulfide elimnd. by adding small quants. of Cu.—*W. Rudolfs.*

Revision of Methods of Determining Nitrates in Water. I. The Diphenylamine Reaction. R. CASARES LOPEZ & L. VILLANÚA FUNGAIRIÑO. Anales fís. y quím. (Spain) **40**:692 ('44). Add 190 ml. of dil. H_2SO_4 (1:3) to 0.1 g. of diphenylamine, add concd. H_2SO_4, stir, note temp. rise, add more H_2SO_4 until temp. no longer rises. This is reagent (**I**). To 1 ml. of water sample add 10 drops of **I**, wash down walls by 2–4 ml. of concd. H_2SO_4 and stir. If large amts. of nitrate present, blue color appears at once; with low nitrate present blue appears in 30 min. About 0.1 mg. of nitrate per l. can be detected. Sample of water must contain no other oxidizing agents. H_2SO_4 used must be freed from nitrate, since all available H_2SO_4 contains nitrate. 70 refs.—*C.A.*

Phosphate Determination in Cooling [Process] Waters. HERMANN RUDY & KURT E. MULLER. Angew. Chem. (Ger.), **A60**:280 ('48). Investigation of application of method of Boratynski and Glixelli to process waters treated with Na hexametaphosphate.

(*Continued on page 40*)



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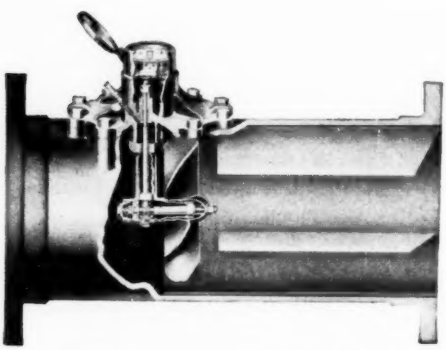
(Continued from page 38)

Detn. of ortho-phosphate by itself and in presence of meta-phosphate described. Effects of foreign matter such as acids, salts, and silicates studied. 30 refs.—*C.A.*

Testing and Purification of Distilled Water. CARL KULLGREN. Svensk Kem. Tid. (Sweden), **60**:169 ('48). Method based upon ion-exchange properties of kraft sulfite cellulose (**I**). Filter made from defibered **I** (3 g.) treated with 200 ml. 0.3 *N* HCl (5–6 portions) and washed with 400 ml. distd. H_2O. In test, filter washed with water to be tested until 2 successive washings (150 ml. each) show same acidity. At this point, developed acidity corresponds to cation-exchange between filter and water to be tested and is, therefore, measure of impurities in it. CO_2 removed before testing by boiling and filter regenerated by repeating above acid treatment. Capac. of above filter about 2l. Filter can be used to conc. and recover impurities and larger filters can be employed for actual purif. of distd. H_2O.—*C.A.*

Simple and Fast Method for Determination of Permanent Hardness in Water. M. BERGMAN. Can. Chem. Process Inds. (Can.), **32**:1125 ('48). Ion-exchange resins (Amberlite IR-100H and IR-4B) rinsed with distd. water and 40 g. of each placed in two 1-l. bottles. Then 300 ml. of tap water added to bottle contg. Amberlite IR-100H, contents well agitated and bottle left standing 1 min. Soln. decanted through filter and 25 ml. of filtrate measured into Erlenmeyer flask and balance poured into bottle

(Continued on page 42)



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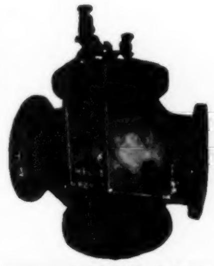

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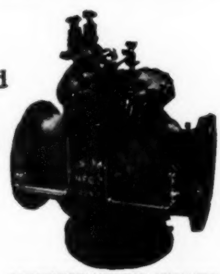

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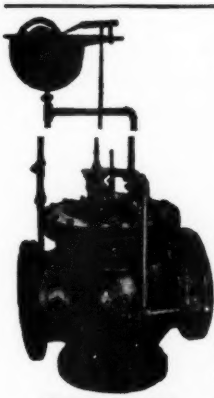

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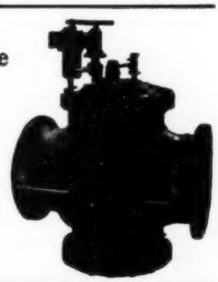

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(*Continued from page 40*)

contg. Amberlite IR-4B, soln. well shaken and left standing 1.5 min. Soln. decanted through filter into first bottle and left standing 1 min. From decanted soln. 25-ml. sample added to 25-ml. sample previously put into Erlenmeyer flask. Combined sample titrated with 0.02 *N* NaOH by using methyl orange. Titration results show permanent hardness.—*C.A.*

Volumetric Method of Determining Total Hardness of Water With Sodium Phosphate. I. N. Ozhiganov. Zavodskaya Lab. (U.S.S.R.), **13**:489 ('47). Neutralize 100 ml. water with 0.1 *N* HCl, using methyl orange indicator. Boil for 2–3 min. to elim. CO_2, add 0.35 ml. (8 drops) of 1% phenolphthalein soln., add several drops of 0.1 *N* alkali until bright pink coloration obtained, and, at temp. not below 65°, titrate with Na phosphate to bright red color. In comparison with results obtained by Blacher method, deviations range from +1.2 to −3%.—*C.A.*

ANNUAL REPORTS

London (Ont.) Annual Report (1947). W.W. Inf. Exch.—Canadian Sec. A.W.W.A., **7**:E:5:10 (June '48). Pop. served 96,771, 100% metered. Avg. pumpage 8.67 mgd. (9.5% increase), 89.6 gpd. per capita. Mains 223.6 mi., meters 21,694, valves 1944, hydrants 1288. Revenue $500,712.96, 6.55% increase. Avg. monthly net bill: domestic $1.15, commercial $10.20. Rates 7–66.5¢/100 cu.ft. plus (for large meters) bimonthly meter rental varying from $1.11 for 1″ to $12.22 for 6″, all subject to 10% discount for prompt payment. Min. bimonthly bill $1.11 gross. Rates

(*Continued on page 44*)

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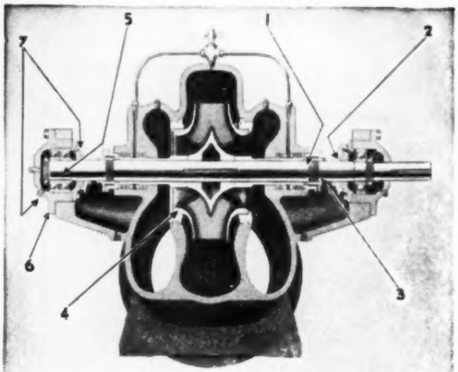

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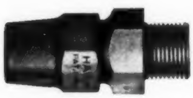
The HAYS reputation for quality is the heritage of 80 years' insistence on honest craftsmanship and fair dealing. The Hays Manufacturing Company is one of the largest in the field and its name is a synonym for the best everywhere. Write for the new HAYS catalog of water works products for every purpose.



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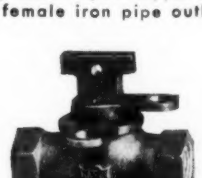

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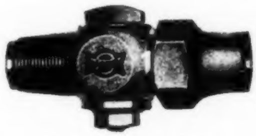
Hays Curb Stop with lockwing for iron pipe A.W.W.A. standard thread.



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(Continued from page 42)

double outside city, except meter rentals. Hydrant rental $18. Assets $3,991,985.68; '47 surplus, $301,976.46. —*R. E. Thompson*.

Stratford (Ont.) Annual Report (1947) W.W. Inf. Exch.—Canadian Sec. A.W.W.A., **7**:E:4:8 (June '48). Supply from wells. Pop. 18,288. Consumption 116 gpd. per capita. Valves 365, mains 45.3 mi., meters 4521 (95.2% metered), hydrants 299. Revenue $66,967.37, expenditures $49,235.47, equiv. to 7.17 and 5.27¢/1000 gal., resp. Metered rates 4.5–15¢/100 cu.ft., less 10% for prompt payment. Min. monthly bill 50¢ gross. Assets $702,089.60.—*R. E. Thompson*.

Halifax (N.S.) Annual Report (1947). W.W. Inf. Exch.—Canadian Sec. A.W.W.A., **7**:E:3:5 (June '48). Pop. 98,719—933 per mi. of mains. Supply through 10.4-mi. pipeline from series of natural lake reservoirs, 992 acres area, with 10,155-acre watershed. Gross value of works $6,987,553.59, revenue $556,617.75, expenses $378,-427.36, provision for depreciation $85,000, debt service charges $185,254.81, deficit $115,256.49. Billing quarterly, large consumers monthly. Uncollectible accts. less than 0.11%. Copper now used for services instead of lead—cost for ¾" pipe, 24 and 67¢/ft., resp. Mains 105 mi. (in city), hydrants 717, valves 1496, meters 14,920. Avg. consumption 11.4 mgd.—*R. E. Thompson*.

Birmingham (Gt.Br.) Water Works. Annual Report (Year Ending Mar. 31, 1948). Wtr. & Wtr. Eng. (Gt. Br.) **51**:515 (Nov. '48). Avg. consumption 44.032 mgd. (Imp.) with addnl. 3.822 mgd. supplied outside statutory area. Reservoirs reached lowest storage on Nov. 3, '47, when only 38 days' storage on hand. Satisfactory progress made on Claerwen Dam. Consent of Ministry of Health received for laying of first installment of fourth main on siphon sec. of Elan Aqueduct and for constr. of 8 units of rapid gravity filtration plant at Frankley water works. Total income for yr. £1,231,697.—*H. E. Babbitt*.

Bombay (India) Water Supply. Annual Report (Year Ending Mar. 31, 1947). Wtr. & Wtr. Eng. (Br.) **51**: 285 (June '48). From Sept. 2, '46, to end of year, water department subjected to strenuous duties on account of fires in city resulting from communal riots. Daily supply for year was 117 mil.gal. (Imp.). Maximum day was 127 mil.-gal. Consumption per person was 75 gpd. (Imp.) based on '41 census, but was estimated at 47 gpd. when floating population taken into account. Repairs to Tansa Dam consumed 3531 cwt. cement. 24-hr. supply

(Continued on page 46)

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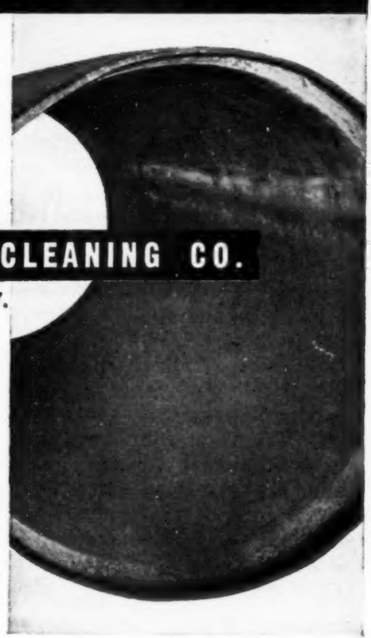

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(*Continued from page 44*)

maintained in only one dist., and this for fear of air locks.—*H. E. Babbitt.*

Georgetown (Penang) Annual Report (1946). First report since '40. Bldgs. and plant not damaged by bombing and but little damage to distr. system. Consumption 8.96 mgd., consumers 240,000. Catchment area 8,500 acres, safe yield (dry year) 7.9 mgd. Filters, five 287.5-sq.ft. and six 434-sq.ft. units. Income $424,732, operation and maint. $221,643, other expenses $166,848. Increased development of supply and plant recommended.—*O. R. Elting.*

Rand (Un. S. Afr.) Water Board. Annual Report (Year Ending Mar. 31, 1948). Board supplies water in bulk to Transvaal Chamber of Mines, South African Railways Admin. and 12 municipalities and villages covering area of 3980 sq.mi. with pop. of 752,000 Europeans and 1,350,000 non-Europeans. Avg. 77.36 mgd., max. 103.5 mgd., min. 60.4 mgd. Munic. areas 621 sq.mi. Pop., European, 657,000; non-European, 983,000; avg. of 40.4 mgd. Capac. of system 90 mgd. Remainder to gold mines and railway plus 2.7 mgd. to minor consumers. Total avg. cost of water in bulk 4.2d per 1000 gal., divided: pumping 1.5d, maint. 1.0d, purif. 0.8d, other 0.9d. Fixed charges and betterments 1.8d per 1000 gal. Source of supply is diversion rights to 215 mgd. from Vaal R. and 10 mgd. from various boreholes and wells. 29.225 mgd. from river has been disposed of to indus. users. Rainfall in Johannesburg 31.27". 59-yr. avg. 33.34". Evap. at Barrage 63.60". 16 yr. avg. 56.0". Board's pipelines total 428 mi. with 16.38-mil.gal. storage at pumping station and 114.88-mil.gal. at various high points. System extends 36 mi. from Vaal R. at Bereeniging to Central Rand and 80 mi. along Witwatersrand from Libanon in west to Nigel in east. Max. pressure on mains 550 psi. Project to increase potable supply 20 mgd. to give total of 110 mgd. expected to be completed by end of '51. Estd. cost £1,811,000. Board employs 344 Europeans and 1326 natives. Cost of plant to date approx. £13,214,000. Outstanding indebtedness £6,870,000 less a redemption fund of £2,717,000.—*O. R. Elting.*

HYDROLOGY

Soil Moisture and Evaporation Investigations. L. A. Ramdas. J. Central Board of Irrigation (India), p. 262 (July '48). Agricultural Meteorology Section at Meteorology Office, Poona, has been engaged, among other activities, in investigating movement of moisture through soil, evapn. from free water and soil surfaces, and effects of certain salts on permeability of soils to water. In this report very brief survey of work in progress made. For fuller information original published papers listed at end of report may be referred to. One of problems studied was evapg. power of air layers near ground; number of exptl. farms over India have been recording evapn. figures and comparing results recorded by several different types of evaporimeters. Evapn. from soil surface found to decrease rapidly with distance between water table and evapg. surface and 2 formulas for computing amt. of evapn. suggested. Formula for evapn. from free water surface also suggested. Formulas based on data recorded in temperate regions may not represent tropical conditions. Investigations also made to det. depth to which plant roots can penetrate in search for water and relation between plant root and shoot development and depth of water table. Further researches on effect of certain salts on black cotton soil, movement of water and salt through soils and

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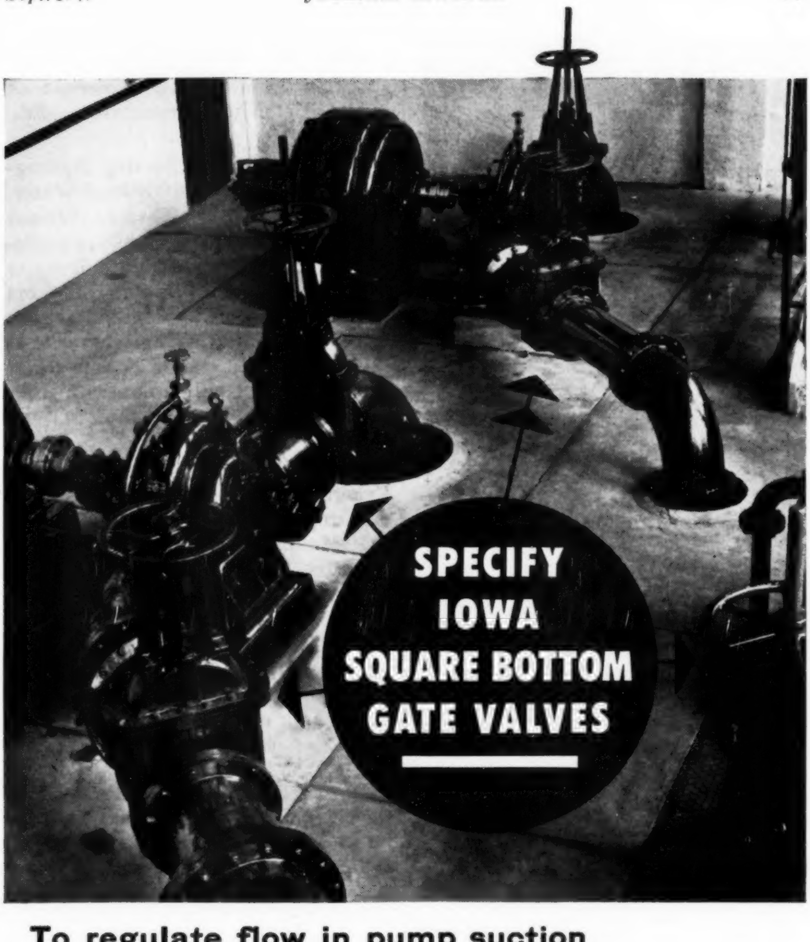

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(Continued from page 46)

adoption of new simple method of estg. soil moisture summarized.—*Ed.*

Geoelectric Studies Serving Hydrography and Search for Ground Water. V. Fritch, Gas, Wasser, Wärme (Austria), **2**:116 (June '48). By geoelectric means ground and fault water as well as direction in which it flows can be determined. Method (either direct or alternating current) allows rapid and cheap search for subsurface waters and in combination with drilling has desired advantages.—*W. Rudolfs.*

Experimental Measurements of Filtering Ability of Arable Soil by the Modified Muntz Method. C. Thirion-Pujos. L'Eau (Fr.), **35**: 169 (Oct. '48). Muntz method consists of graduated 5–10-l. water-filled bottle, with rubber stopper contg. 1-cu.m.-diam. glass tube, placed upside down on cylindrical stand (25 cu.m. high and 11.2 cu.m. in diam.) thrust into soil. Modified method consists of bottle of 2.5 l. and larger base to relieve pressure on soil. One device placed on cultivated soil and another on uncultivated or on land covered with grass, clover or other perennial crop. Measurements made every 15 min. for about 2 hr., or until absorption curve flattens. Filtration coefficient calcd. from amt. of water absorbed in given time. Comparisons of different soils with different crops indicate water required for irrigation. —*W. Rudolfs.*

BRITISH SUPPLIES

Greater London's Water Supplies. Anon. Surveyor. (Gt. Br.), **107**:405 (Aug. 6, '48). Because rising water consumption might bring about serious water shortage in drought years, departmental committee believes that inquiry should be made into water

(Continued on page 50)

WORTHINGTON-GAMON

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(Continued from page 48)

resources and prospective demands of area. Plans should be made for new major source of supply. Resources of areas must be treated as whole, and central authority for area necessary. Strong evidence that there has been greatly increased consumption per head per day since war. Consumption will rise owing to: higher stds. in modern homes; increased demands by industry and new towns; dist. heating; and extensions into rural areas.—*H. E. Babbitt.*

Some Water Supply Problems in Northeast Essex. J. S. ORCHARD. J. Roy. Sanit. Inst. (Gt. Br.), **68**:148 (May '48). Interesting and instructive article dealing with yield of underground (chalk) and surface sources and water supply demands of pop. served. Dist. discussed embraces entire catchment area of Essex Colne. Contains 220 sq.mi. and pop. of 106,400 served by public water supply. In Colchester, city of 72,000, per capita demand anticipated to be 54 gpd. (U.S.) in 1960, with avg. per capita demand of somewhat more than 50 gal. and total daily requirement of 6.5 mgd. for district considered. Chalk has been fissured by unequal pressures of eroded overburden consisting of clayey Eocene beds and London clay. Chalk deposits are 500′ thick, but because of clay blanket only 24 sq.mi. receive percolation water estd. to amt. to 2″ annually from yearly rainfall of 24″. Wells in chalk and gravel springs estd. to have safe yield of some 3.0 mgd., leaving 3.5 mgd. to be obtained otherwise. Suggested source is Colne R. water pumped into impounding reservoir located in lateral valley and containing 1200 mil.gal. This water will be turbid at times, relatively hard and pold. with sewage. Therefore proposed to be treated in lime-soda softening plant using rapid gravity filters with final chlorination.—*P.H.-E.A.*

Wallasey Corporation Water Works. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **51**:476 (Oct. '48). Undertaking responsible for supply and maint. of service to residential area, comprising County Borough of Wallasey—with exception of Saughall Massie. Daily quant. of water used for all purposes avgs. 3.75 mgd.(Imp.), equiv. to 36.8 gpd.(Imp.) per head. Water derived from bulk supply of 3.0 mgd. from Alwen watershed; and underground waters pumped from boreholes at Liscard Pumping Sta. Alwen Aqueduct approx. $42\frac{1}{2}$ mi. long. Pumping station comprises 4 boreholes, between 171′ and 900′ deep. In '47 elec. power for centrifugal pumping units approved. First unit erected of std. type, with capac. of 0.5 mgd., comprises 50-hp. vertical-spindle motor at

(Continued on page 52)

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(Continued from page 50)

ground level, with centrifugal pump at depth of 140′. Next 2, submersible pumping units, each of 0.91-mgd. capac. installed. One submersible pumping unit maintd. in service over test period of 12 mo., during which it operated for 4376 hr. at full capac. On completion, pump lifted and dismantled for inspection. Pump found in perfect condition, without indication of wear or defect. Evidence of electrolytic action found in motor unit in consequence of which slight alterations made and plant returned to service. Second unit has completed 2850 hr. of pumping during 6 mo. under water. Will probably be withdrawn for inspection at end of 5000 hr. Softening plant comprises 6 units designed for fully automatic control for brine regeneration of zeolite. At Gorsehill Res. processed well water and bulk supply of Lake Alwen mixed.—*H. E. Babbitt.*

Rural Water Supplies. GEORGE W. CURTIS. Surveyor (Gt. Br.), **107**:327 (June 25, '48). Original conception of piped water supplies as grid schemes over large areas seems completely dissipated. Experience in urban schemes showed that pops. increased, high percentage of connections could be expected, consumption increased and distr. of pop. remained relatively static. Under rural conditions, good reason to doubt pop. increase; will be economically impossible to reach all of low-density rural area with water supply schemes; rate of connection to mains will be relatively small after first rush; consumption will not reach even reasonably high figures until baths, water closets and so on introduced. Physically impossible to put them into many old country houses without constr. of addns. out of proportion to value of cottages. New houses replacing cottages scattered about rural dists. will result in transfer of pop. from one location to an-

(Continued on page 54)

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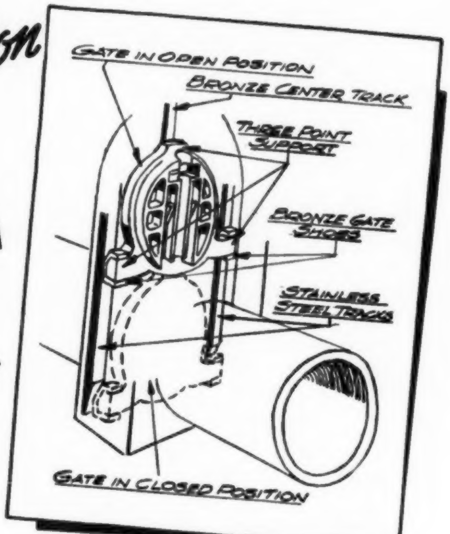

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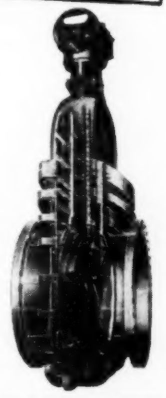

WHAT 3-POINT SUPPORT MEANS

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3—Valve can be used for throttling without damaging seat rings.
4—The gates are properly supported for operating in vertical lines.

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3

(Continued from page 52)

other. Question raised whether it would not be better to rely on independent scheme for each parish or at most 2 or 3 parishes. Constr. of numerous small headworks, each providing water-pumping load near village, would facilitate rural electrification. Prelim. stage of such plan would involve design of complete village scheme. General recommendations: [1] local authority must conduct prelim. investigation in order to give engr. definite recommendations; [2] plan parish and not dist.; [3] consider probable cost, ascertain probable revenue and consider whether particular length of main worth it; and [4] plan piped water supply to accord with other social services.—*H. E. Babbitt.*

Rural Water Supplies and Sewerage. A. E. Chapman. Wtr. & Wtr. Eng. (Gt. Br.), **51**:421 (Sept. '48). Many houses and farms exist to which public mains can never be taken if reasonable cost considered. Unless changes made in procedure in water supply in rural dists. and amt. of financial assistance increased, unsatisfactory conditions will in some instances continue. Some changes or alterations that could be introduced: [1] larger grants to poor areas and loans free of interest; [2] grants from Ministry of Agriculture; [3] meter supplies and std. charges; [4] less incidental expense; [5] formation of joint water areas; [6] estd. demands (general practice in estg. domestic need is to add 25% to '31 census figures and allow 30 gpd.(Imp.) per cap. (these figures excessive and make no allowance for: (*a*) isolated farms unlikely to be supplied; (*b*) private installations unlikely to be superseded; (*c*) hamlets likely to remain without sewers; and (*d*) stock watered on permanent water pastures); [7] reduction of road reinstatement costs; and [8] development of schemes by stages.—*H. E. Babbitt.*

Rural Water Supplies. George W. Curtis. Wtr. & Wtr. Eng. (Gt. Br.), **51**:426 (Sept. '48). All evidence pointed to fact that in majority of chalk areas farmer would be far better off by providing own small source of supply, particularly since grants available from Ministry of Agriculture. All schemes based upon estd. max. consumption of 30 gpd.(Imp.) per head based on '31 census. Distr. systems designed substantially for domestic purposes only. Examn. of 14 dist. schemes reveals 1 mi. of main per 111.3 persons. On avg., total length of main involved in whole system 50% made up of link mains between villages. Potential revenue along these links almost negligible. Actual cost of linking villages represents at least 50–60% of total cost.

(Continued on page 56)

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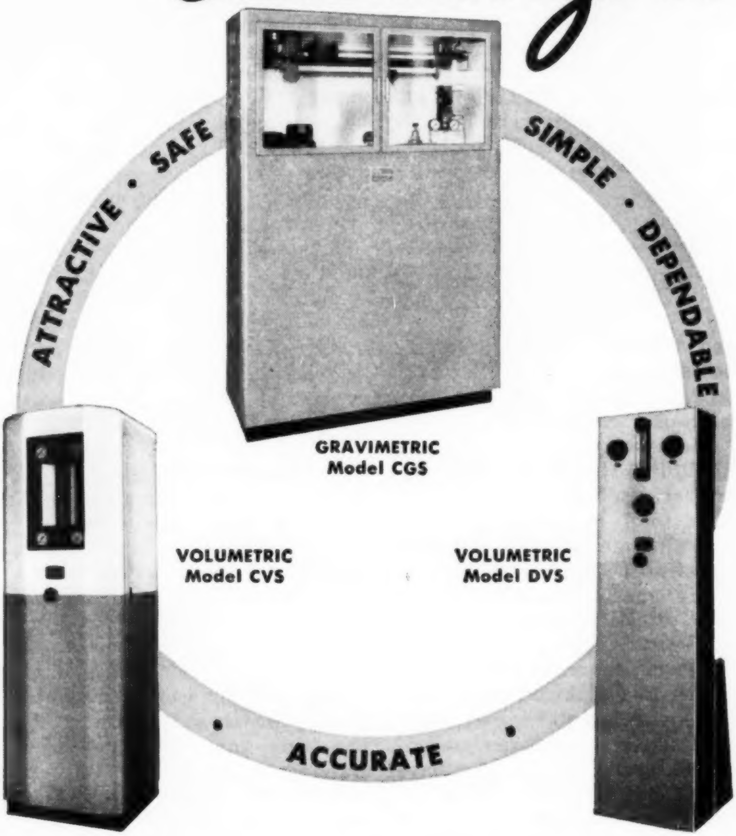

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BUILDERS PROVIDENCE
Instruments

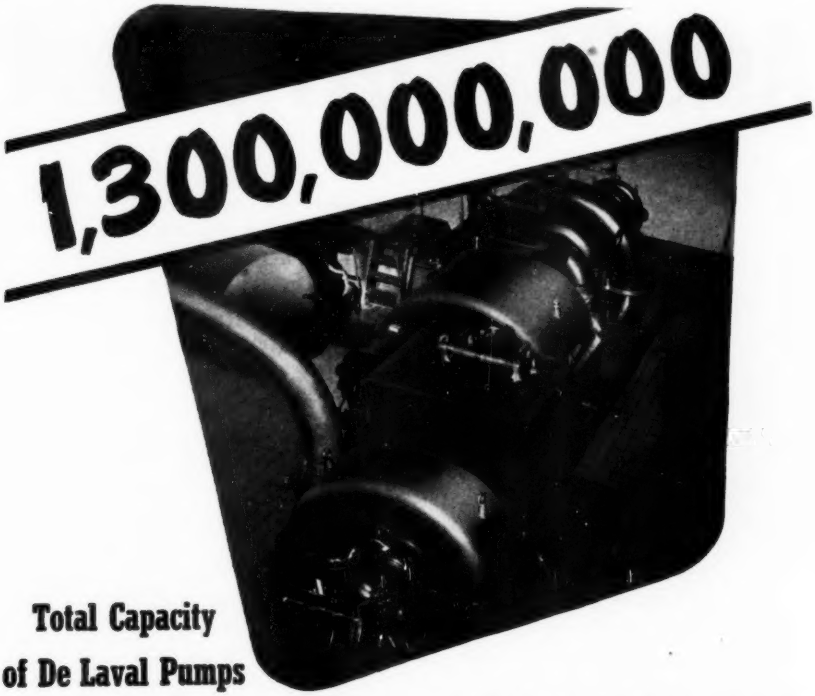
(*Continued from page 54*)

Anal. of existing rural mains in country led to conclusion that: [1] although existing mains within reasonable distance of 90% of properties, only 64.6% have connected; [2] avg. consumption per cap. 15.6 gpd. Long period between inception of schemes and time of max. consumption. For considerable period independent scheme may be more sensible. Seems more practical to adopt 2-stage program, prelim. stage to involve design of complete scheme. This to be followed by introduction of small village headworks supplying builtup parts of village, but designed to accord with ultimate scheme. Final stage replacement of village headworks with major dist. scheme headworks with trunk mains to villages.—*H. E. Babbitt.*

Glasgow Water Supply. Gorbals Works Centenary. ANON. Surveyor (Gt. Br.), **107**:510 (Oct. 1, '48). Gorbals works commissioned in 1848 and taken over by Glasgow Corp. in 1855. Today Gorbals works contributes between 5 and 6 mgd. (Imp.) to city's total requirements of 80 mgd.(Imp.), remainder being supplied by Loch Katrine works. In Gorbals works avg. annual rainfall of 48″ on watershed of 2,500 acres stored in 4 reservoirs with total water surface of 226¼ acres and capac. of 1058 mil.gal. (Imp.). Artificial watercourse from Brock Burn leads water to reservoirs. 2 sets of filters; lower have area of 3773 sq.yd. and 7 upper filters have area of 7267 sq.yd. Water conveyed from clear-water tanks to supply areas by two 24″ cast-iron mains.—*H. E. Babbitt.*

Gathering Grounds. Public Access, Afforestation and Agriculture. Summary of the Report of a Subcommittee of the Central Advisory Water Committee Appointed by Minister of Health. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **51**:350 (Aug. '48). Main object of restriction imposed on agriculture and public access is prevention of waterborne disease. If catchment areas protected to preserve water from human contact, spread of diseases by water would be eliminated without need for purification. No system designed to exclude human access likely to be enforced in practice. Possibility would remain of pollution by sea gulls. Significant that in no instance in England has disease been transmitted by pollution of large reservoir. Filtration primarily intended to remove suspended solids from water, but few germs will survive it. Those that do are dealt with by sterilization. Used alone sterilization not satisfactory. Bacteriological analysis plays essential part in provision of pure water. Weakness of *Esch. coli* as warning agent is that it is not confined to humans but is emitted in feces of all warm-blooded animals. Research into practical method of differentiation between human and animal pollution continuing. Committee considers it going too far if land withheld from productive use on grounds that occasional presence of defecating cow or dead sheep in feeder streams is "not a nice idea." No one has proposed that reservoir ought to be kept free of fish. As to practices of upland utilities, few have bought whole of watershed, some have bought greater part, some small part and some none at all beyond what was required for reservoir. Some utilities endeavor, with varying success, to prevent all human access except by own staff. Some exclude general public but allow sporting tenants. Some try to confine public to recognized paths. Some allow restricted boating, and some attempt no control. One or two have demolished farmhouses and try to exclude all animals. Most allow or encourage sheep. Many prohibit cattle and

(*Continued on page 60*)



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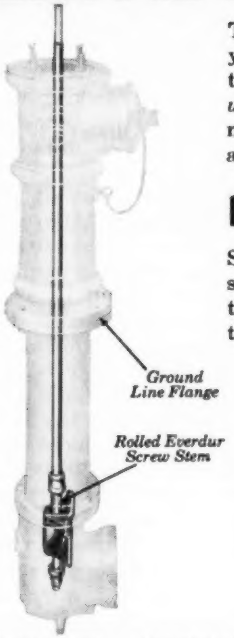
(Continued from page 56)

cultivation. Few make no attempt to prohibit farming of any kind but arrange for safe disposal of sewage. In face of diversity of practice, suggested by British Waterworks Assn. that no attempt be made to lay down uniform policy. Each utility's opinion of what precautions are necessary should be regarded as sacrosanct. Every attempt to remove any wild and beautiful country from reach of people who appreciate it must receive critical attention. Policies of water works today do have undesirable effects in spheres of access and of agriculture and can be justified only if it can be shown that nothing less would be sufficiently effective. Many large river-using utilities have only two lines of defense of any reliability—filtration and sterilization. Systems using habitually polluted source without long storage commoner in America than in England, and so are waterborne diseases. Committee would not, therefore, encourage reliance on purification alone. Chlorination without filtration cannot usually be regarded as effective. In many small water works, standard of safety is lower, and in some, imposition of restriction not now in force might well be advisable. Use of heavily polluted source with reliance on treatment alone not course to be followed when avoidable. Use of supposedly unpolluted surface source with reliance on storage and chlorination without filtration falls short of desirable standard. Reasonably pure source, combined with long and secure storage and adequate treatment by both filtration and chlorination, appears to be thoroughly satisfactory. Principle to be followed in control of catchment areas is to keep water entering reservoir free from gross pollution; reservoir, and sometimes feeder streams, should be so protected as to prevent fresh sources of pollution from entering; and between reservoir and consumer

(Continued on page 62)

SERVICE . . . *with a monkey wrench!*



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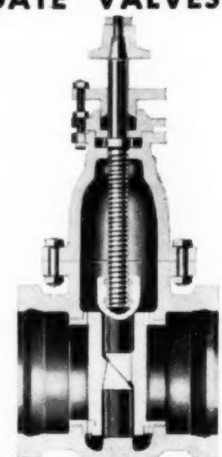

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(Continued from page 60)

there should be efficient filtration and sterilization. By gross pollution is meant regular discharge of sewage or sewage effluent. So far as water purity concerned, essential to limit camping and trailer parking to approved sites where either proper sewage disposal exists or distance of reservoir and nature of intervening land preclude risk of pollution. Since it would be quite impossible to control urination by bathers, committee opposed to bathing under any conditions. Greatest freedom should be allowed to all farming activities and it should be responsibility of utility managers to insist on productive use of land. It sometimes happens in times of exceptional drought that largest impounding reservoirs reduced below month's storage. First line of defense may be regarded as temporarily inoperative. In certain exceptional areas, vagaries of geological formation may make it desirable to impose more widespread limitations on use of land for protection of wells and boreholes. In most such areas land subject to restriction is so small in extent as to be matter of no importance to other interests. Desirable for all land which will grow trees and cannot more advantageously be used to be afforested.—*H. E. Babbitt.*

Protection of Water Supply Catchment Areas. ANON. Civ. Eng. (Gt. Br.), **42**:527 (Dec. '47); Wtr. & Wtr. Eng. (Gt. Br.) **51**:12 (Jan. '48). Extracts from an address by John Stewart before Annual Congress of the Royal Sanitary Assn. of Scotland. As far back as 1847 Water Works Clauses Act empowered water authorities to make provision for protecting catchment areas. Very few authorities at that time availed themselves of that power. In 1919 Glasgow became alive to situation and purchased approximately 25,000 acres for purpose of complete control to

(Continued on page 64)

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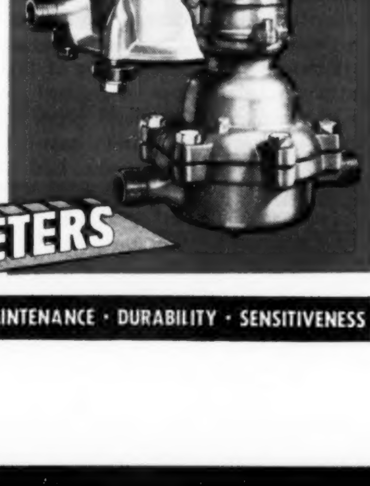

BADGER Water METERS

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(Continued from page 62)

keep water pure. If right of access be given, water authorities might have to resort to great schemes of filtration. It would be of utmost value to know what water engineers thought of proposal to include their watersheds in national parks. Because of purity of supplies from catchment areas in Scotland, elaborate filtration plants seldom required. Water authorities should be given following safeguards before and if national parks become law: [1] consultation between minister and water authorities; [2] if proposals of minister unacceptable, local public inquiry should be authorized; [3] if water authorities unable to accept findings of local inquiry, inadequately safeguarded water areas should be omitted from scheme.—*H. E. Babbitt.*

Early British Water Works. Jonathan Davidson. Surveyor (Gt. Br.), **107**:583 (Nov. 5, '48). Drake's Leat one of oldest munic. water supplies in England, being authorized in 1585. Intended for watering ships, fire protection, scouring harbor and removing refuse from tin works and mines. It continued as Plymouth's main source of supply, with little modification, for more than 300 yr. Through King James I, in 1612, Sir Hugh Myddleton, with proper credit to Capt. Edmond Colthurst of Bath, brought water from New River to London in trench 10′ wide. Detailed accts. of expenditures, rates of pay and methods of constr. Laborers received 10d per day; excavation carried on at piecework rates. Up to beginning of 19th century wooden pipes in general use for water distr., with lead pipes for house connections. First cast-iron pipes in London, of any size, laid by Chelsea water works in 1746 but did not come into general use until 1810. First attempts to filter water on large scale through sand probably made early in 19th century by mfg. firms in Lancashire. Earliest attempts to filter water for public supply made in Clyde Valley in Scotland in early years of 19th century. First installation of self-cleaning filters by reverse flow of water at Greenock in 1826–29. Simpson's expts. at Chelsea water works included upward, downward and lateral flow, filter being constructed in 1827. Full-size filter constructed at Chelsea on Jan. 15, 1829. Earliest example of sterilization of water by chem. means at Maidstone in 1897, in connection with outbreak of typhoid fever. Most striking example of chlorination at military field in 1914–18.—*H. E. Babbitt.*

Research in the Water Industry. Norman J. Pugh. Wtr. & Wtr. Eng. (Gt. Br.) **50**:453 (Sept. '47). Tendency on part of responsible bodies to avoid possibility of disturbing public on matters affecting their water supply gives rise to reluctance to give publicity to causes of doubt or difficulty affecting them. Comparatively few authorities can be expected individually to provide facilities and employ qualified staffs for extensive research. Potentialities for investigation and research presented by national, technical, academic and industrial organizations, together with research facilities within water works industry itself, surely sufficient to meet all needs, provided these needs can be defined. There is lack of facilities for cooperation between research workers in labs. and water works personnel coping with day-to-day problems. Investigations now proceeding under guidance of British Waterworks Assn.'s Research Coordination Committee are: [1] supersonic frequencies—in relation to protection of reservoirs and in water treatment; [2] algal growths—recognition, anticipation and inhibition; [3] sterilization of water—research in use of chlorine and ozone; [4]

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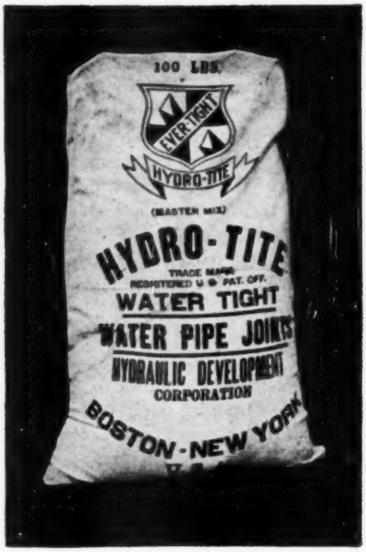
HYDRO-TITE



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Main Sales Office: 50 Church St., New York, N. Y.

Works: West Medford Station, Boston, Mass.

(*Continued from page 64*)

corrosion of pipelines—use of noncorrodible materials and jointing methods and materials, and poln. in process of handling; [5] hydrology—application of statistical methods to water works problems, especially rainfall, runoff, evapn. and yield; [6] water works fittings—materials, with special reference to hot-pressed and cast fittings; [7] mechanics of filtration—new group recently formed; [8] standardization of chem. anal.—new group in course of development in collaboration with Royal Inst. of Chemistry. Steps should be taken in encouraging international exchange of information, with coordination of international research as final objective. There is no big initial financial obstacle. First step is to team up present resources and exploit existing potentialities. Following might be considered appropriate subjects in which research might be initiated and coordinated by British Waterworks Assn.: standardization of administrative methods, possible effect of chem. constituents in potable waters on health of consumers, recommendation of appropriate provisions in estg. future domestic consumption, provision to be made for water supplies for agricultural purposes, consumer and economic aspects of softening of water supplies, and waste prevention and detection.—*H. E. Babbitt.*

Abstraction of Water Supplies from Rivers. C. H. H. MERCER. Civ. Eng. (Gt. Br.) **44**:92 (Feb. '49). Local resources must be used before supplies brought in from long distances, and should be used to supplement, not supersede, local supplies. Taking of water from surface supplies usually relatively simple. When considering abstraction from rivers, following should be taken into account: [1] flow available; [2] quantities taken from river for all purposes, excluding livestock requirements; [3] quantity of

(*Continued on page 68*)

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This patented fish control method employs modern electronics in overcoming a serious operating and maintenance problem. Fish of all sizes are kept at a *safe distance* from intake structures, or screens, by the use of an Electronic Control Unit. This equipment, generating special electrical impulses, energizes an electrode system designed and engineered for your particular fish control problem.

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for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc. has confirmed your judgment.

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(*Continued from page 66*)

sewage discharged into channel above and below intake; [4] acreage of agricultural lands adjoining watercourse and dependent on river for subsoil water; and [5] agricultural requirements of area. Livestock requirements computed on basis of 30 gpd. (Imp.) per head for dairy cattle, and 10 gpd. for other stock.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Waterborne Diseases. I. H. BORTS. Am. J. Pub. Health, **39**:8:974 (Aug. '49).

Pollution of the Androscoggin River by Industrial Wastes and Control Measures Thereof. E. SHERMAN CHASE. J. Boston Soc. Civ. Engrs., **36**:3:357 (July '49).

$98,000,000 Estimate of Cost to Remedy Pollution of Two Boundary Channels (Interim Report to the International Joint Commission by the Board of Technical Advisers). Wtr. & Sew. (Can.), **87**:7:31 (July '49).

Introduction of Prechlorination of Slow Sand Filters. SAMUEL JACOBSON & MARSHALL S. WELLINGTON. J.N.E.W.W.A., **63**:2:128 (June '49).

Effect of Temperature on pH of Alkaline Waters. JEROME GREEN. Ind. Eng. Chem., **41**:8:1795 (Aug. '49).

Report of Committee for Survey of Ground Water Supplies in New England. J.N.E.W.W.A., **63**:2:175 (June '49).

Effect of Setting on Performance of Centrifugal and Propeller Pumps. ROBERT W. ANGUS. Wtr. & Sew. (Can.), **87**:7:27 (July '49).

Radial Cone Tank at Columbus

The City of Columbus, Miss., installed this 750,000-gal. radial-cone bottom tank to provide gravity pressure in its water distribution system. The structure is 89 ft. to the bottom and has a range in head of 35 ft. between the upper and lower water levels. Write our nearest office for estimating figures on elevated tanks or flat-bottom steel reservoirs when planning waterworks improvements.

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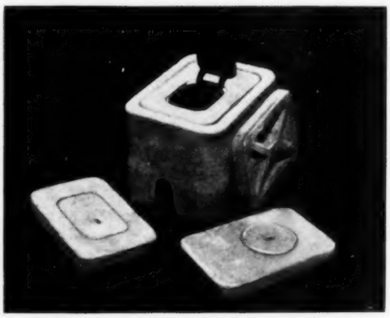
(*Continued from page 20*)

"Pie in the Sky" was the way we characterized a one-time discussion of running an 1100-mile, atomic-pumped transmission line from the Columbia River to Southern California, thus to solve a flood problem on the one hand and a water problem on the other. The idea appeared a little less pie-eyed when we learned later that the atomic pumping plants were not included in the serious proposal. So we are perhaps less shocked now to find that it was necessary recently for Secretary of the Interior Krug to assure the people of the Pacific Northwest that only the excess water from their streams would be appropriated if the idea of piping them not only as far south as San Diego but as far east as Denver was found feasible. Pipe dream or no, this kind of talk is going to give people the idea that water is indispensable.

William A. Marsteller of Chicago and Robert P. Melius of Milwaukee have been elected Vice Presidents of Rockwell Mfg. Co.

R. F. Hutchinson has been added to the Dearborn Chemical Co. staff, serving the Nebraska, South Dakota and western Iowa territory.

(*Continued on page 72*)



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EDDY

VALVE COMPANY

WATERFORD NEW YORK

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(*Continued from page 70*)

The stability of fire hydrants has long been an established fact, ruefully reestablished at times by various vehicular vagrants. In recent months, however, demands for a portable plug have led to the construction of a number of hydrants of the false-alarm type. First of these impotent imitations was used by the Lord & Taylor department store in a streetside Christmas display which saw Santa Claus's sleigh being tagged for improper parking by a dummy policeman. Second was a wooden brainchild of well-known muralist Hugh Troy, who, irritated with his inability to find a parking space outside his apartment, placed an imitation plug on the sidewalk to reserve a space, removing it each day after he had parked his car. But the last word in deceit was that featured at Bloomfield, N.J., last June.

Made of cast iron, the Bloomfield hydrant is accurate in its every detail, with two nozzles, pentagonal operating nuts and all the technical trimmings, except, of course, it has a flat base at the ground line so that it may be set down at any desired location. Not intended for the imaginative window trimmer or the petulant parker, however, this ingenious imitation is being sold at a pet shop. The model we inspected measured one and one-half feet in height, but presumably a variety of sizes is available to accommodate different breeds. No, it cannot be flushed.

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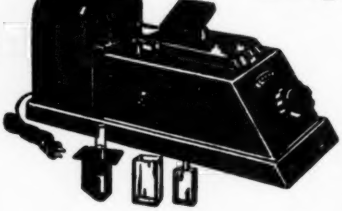

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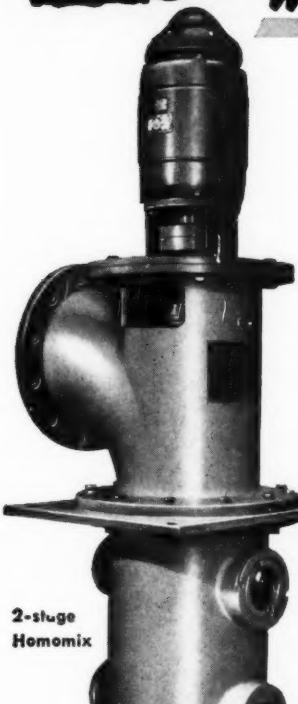

2-stage Homomix

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The HOMOMIX gives instantaneous, violent, and uniform mixing of one or more chemicals, or gases, with water. *Immediate, total diffusion*—the most important factor for the efficient and economical addition of chemicals or gases—is obtained *without the use of a mixing tank!* For new plants it eliminates the necessity for costly mixing tank construction; for existing plants it can be effectively used to improve treatment.

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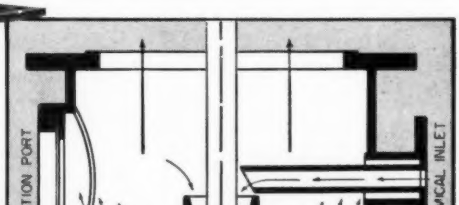

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An ultrasonic generator for experimental purposes has been produced by the Special Products Div. of General Electric. Offering four operating frequencies—300, 500, 750 and 1,000 kc.—the generator utilizes 500 electrical watts to produce from 200 to 250 acoustical watts. This is accom-

plished by converting high-frequency electrical power into mechanical vibrations through the piezoelectric effect of a quartz crystal. The crystal forms the bottom of a test well filled with insulating oil, in which material to be tested can be placed—inside a beaker or other container—for direct exposure to the "sound" waves. Additional information is in publication GEC-544, available from the General Electric Co., Schenectady 5, N. Y.

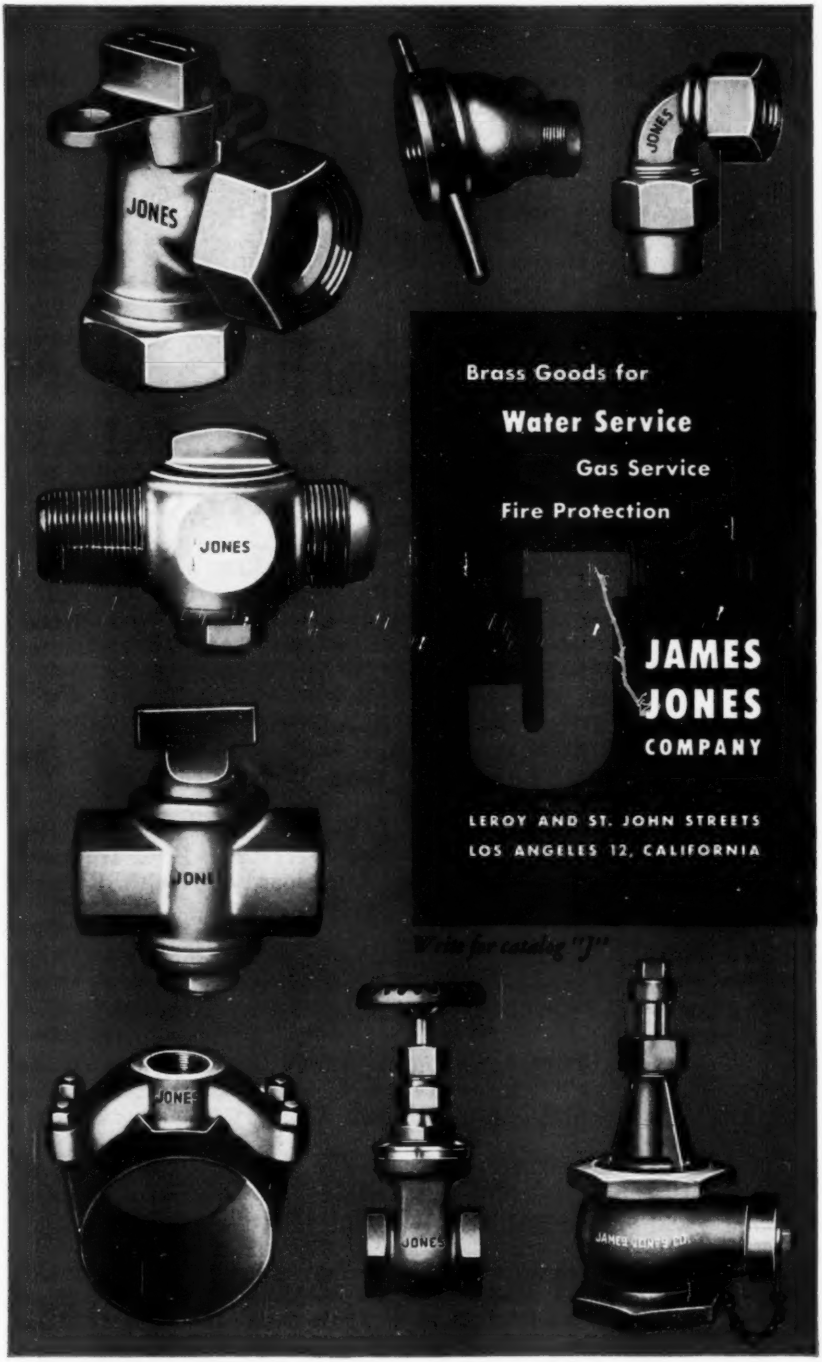
Recent studies have indicated the possible value of both audible and inaudible sound waves of high intensity in the destruction of bacteria and algae in liquids, and the flocculation of suspended particles in both liquids and gases. The audible range of frequencies ends at about 20 kc.

Reprints of an article on "Cathodic Protection of Galvanized Hot Water Storage Tanks by Use of Galvanic Magnesium Alloy Anodes" by D. J. Fergus are available from The Cleveland Heater Co., 2310 Superior Ave., Cleveland 14, Ohio. The 16-page pamphlet is known as Educational Bulletin EB–104.

A 28-page booklet which traces the development, principles, design considerations, operation and application of the Accelator has been issued by Infilco Inc., 325 W. 25th Pl., Chicago 16. The bulletin, No. 1825, is entitled "The Accelator: The Modern, Proven High-Rate Water Treating Plant."

"Kennedy Bronze Globe and Angle Valves With Renewable Composition Disc" is the title of a folder distributed by Kennedy Valve Mfg. Co., Elmira, N. Y. Cut-away and other illustrations explain the important operating features, and a table gives dimensions of ¼- to 3-in. sizes. Requests should specify Circular 101.

Gale Liquid Interceptors and Conditioners for the trapping of oils, greases, fats, solvents, etc., in waste lines are described and their functions explained in a series of brochures available from the Gale Oil Separator Co., Inc., 52 Vanderbilt Ave., New York 17, N.Y. A good package to have sent to that upstream polluter.



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(Continued from page viii)

October **19–21**—Alabama-Mississippi Section in Jackson, Miss. Secretary: John L. Snow, Dist. Engr., Layne-Central Co., 601 First National Bank Bldg., Montgomery 4, Ala.

24–25—Virginia Section at Roanoke Hotel, Roanoke, Va. Secretary: W. H. Shewbridge, Asst. Engr., State Health Dept., 713 State Office Bldg., Richmond 19, Va.

26–28—California Section in Sacramento, Calif. Secretary: H. C. Medbery, Chief Water Purif. Engr., Water Dept., 425 Mason St., San Francisco 2, Calif.

31–Nov. 2—Kentucky-Tennessee Section at Lafayette and Phoenix Hotels, Lexington, Ky. Secretary: R. P. Farrell, Director, Div. of San. Eng., State Dept. of Public Health, 420—6th Ave., N., Nashville 3, Tenn.

November **2–4**—Chesapeake Section at Wardman Park Hotel, Washington, D.C. Secretary: Carl J. Lauter, 5902 Dalecarlia Pl., N.W., Washington 16, D.C.

3–4—Ohio Section in Dayton, Ohio. Secretary: F. P. Fischer, Sales Engr., Wallace & Tiernan Co., Inc., 812 Perry Payne Bldg., Cleveland 13, Ohio.

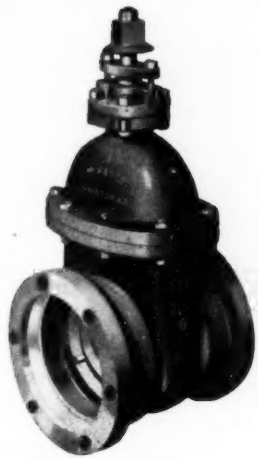
7–9—North Carolina Section at Highland Pines Inn, Southern Pines, N.C. Secretary: E. C. Hubbard, Prin. San. Engr., State Board of Health, Raleigh, N.C.

11–13—Arizona Section at San Carlos Hotel, Yuma, Ariz. Secretary: Mrs. Helen Rotthaus, San Eng. Div., State Dept. of Health, Phoenix, Ariz.

14–16—Florida Section at Orange Court Hotel, Orlando, Fla. Secretary: A. E. Williamson Jr., P.O. Box 1431, Daytona Beach, Fla.

17–19—New Jersey Section at Madison Hotel, Atlantic City, N.J. Secretary: C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

December **5–7**—Southeastern Section at Gordon Hotel, Albany, Ga. Secretary: T. A. Kolb, San. Engr., State Board of Health, Wade Hampton Bldg., Columbia, S.C.



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A.W.W.A. type M&H Valves and Hydrants are now offered with standardized mechanical-joint as adopted by the Cast Iron Pipe Industry. Our mechanical joint valves and hydrants may be used with mechanical joint Cast Iron Pipe without any necessity of special fittings to make installations. This standardized mechanical-joint has a stuffing box into which a gasket is compressed by a Cast Iron gland and bolts. It permits deflection and is a highly successful pipe joint for water mains, gas mains, sewage treatment plants, water filtration plants and practically all kinds of industrial piping.

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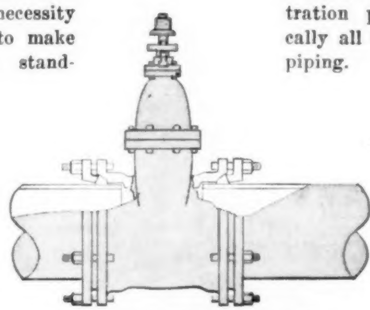

Illustration of how Mechanical-Joint Gate Valve is installed.

Of course, we continue to make M&H Valves and Hydrants with bell-and-spigot, flanged or screwed joints.

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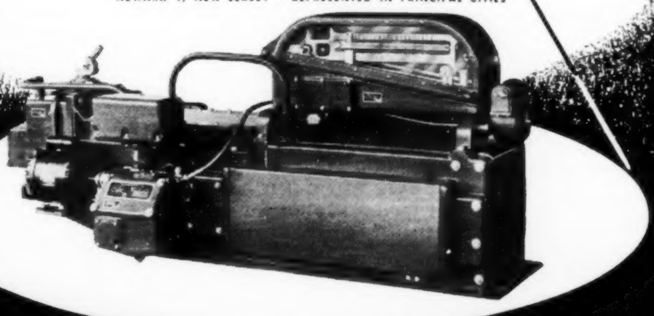

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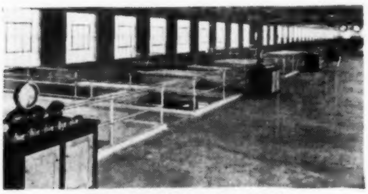
DeLaval Steam Turbine Co
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

IT'S ROBERTS FILTER at ECUSTA

WATER FILTRATION PLANT—Ecusta Paper Corp., Pisgah Forest, N. C., Capacity 22,500,000 gallons per day, J. E. Sirrine & Co., Greensville, S. C., Consulting Engineers.



THE OPERATING GALLERY

THE SAMPLE TABLE for circulating and drawing samples of water at different points in process of treatment and from effluent of each filter—Laboratory in background.

THE PIPE GALLERY at the Front of the Filters

Where Pure Water is more than important . . . it is ESSENTIAL

The consistent high quality of Ecusta cigarette paper depends directly on the continuous supply of pure water coming from their Roberts equipped filtration plant—one of the most modern installations in industry today.

Municipalities as well as industrial plants have long recognized the year-in year-out dependability that is built into every Roberts installation.

MECHANICAL EQUIPMENT
BY
ROBERTS FILTER MFG. CO.
DARBY, PENNA.

ROBERTS FILTER MANUFACTURING CO.
638 COLUMBIA AVENUE • DARBY, PENNSYLVANIA

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

oversize water lines are "DOLLAR-GOBBLERS"

Why pay extra money for excess weight and material in water supply and force mains? By specifying ARMCO Steel Pipe you can get top efficiency and also save money.

ARMCO Pipe diameters range from 6 to 36 inches; wall thicknesses from 9/64 to 1/2-inch. From that wide range you can match job requirements with the right wall thickness in any diameter. You may even be able to select a smaller diameter than you expected because ARMCO Steel Pipe has a smooth, spun-enamel lining that provides utmost hydraulic efficiency. It prevents tuberculation, assures continued high flow capacity and stops costly cleaning.

ARMCO Welded Steel Pipe has a high strength-to-weight ratio that withstands internal or external pressures. It flexes with the load to guard against explosive bursting due to vibration or sudden overload. Leakage is no problem because standard couplings or field welding provide tight joints. Special prefabricated fittings save time and money. A wide variety of protective coatings meet specific service conditions.

Specify ARMCO Welded Steel Pipe for your next water supply line with full assurance of long economical life. Write us for complete information. Armco Drainage & Metal Products, Inc., 185 Curtis Street, Middletown, Ohio.

ARMCO

ARMCO WELDED STEEL PIPE

MEETS A.W.W.A. SPECIFICATIONS

the "Great Gildersleeve"

STARRING HAROLD PEARY—ON THE AIR FOR KRAFT FOODS COMPANY OVER N.B.C.

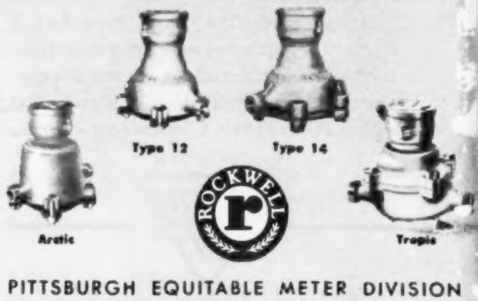
. . . IS BROADMINDED ABOUT READING METERS

Commissioner Gildersleeve tells newly hired Meter Readerettes, "Your job is to make consumers drool . . . so they'll be thirsty . . . so they'll drink more water." He peers at the . . . well, at the efficient Pittsburgh water meter.

The girls eagerly lap up Gildy's instructions as he says, "Accuracy is our watchword and if you can't be accurate at least be on our side." His explanation is quite clear.

As the Commissioner concludes his instructions on the art of meter reading, the girls' interest and enthusiasm know no bounds. They're ready to read 'em and reap for dear old Summerfield.

PITTSBURGH-EMPIRE METERS

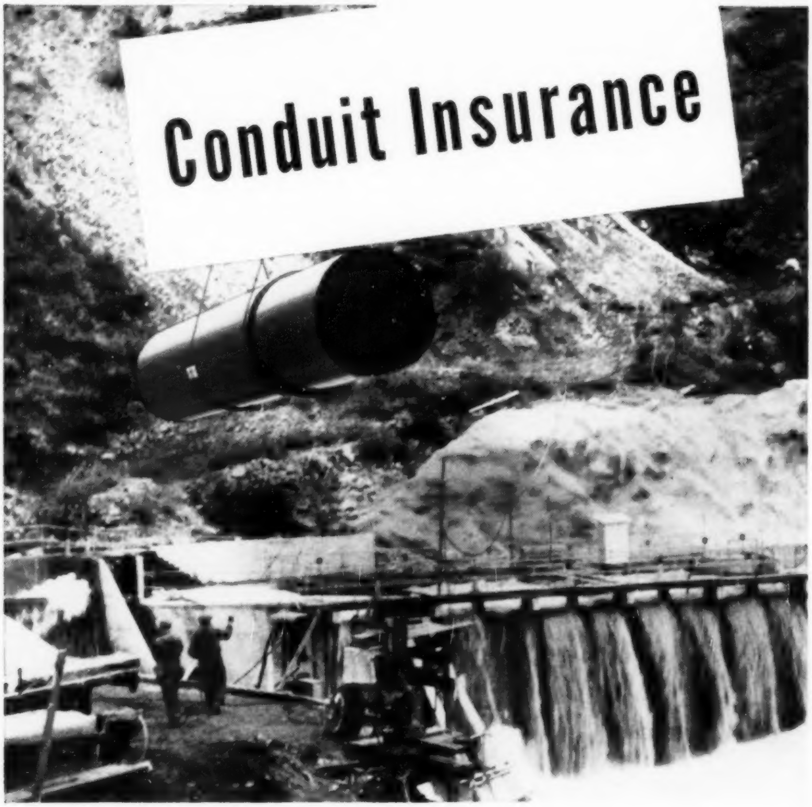


PITTSBURGH EQUITABLE METER DIVISION
ROCKWELL MANUFACTURING COMPANY
PITTSBURGH 8 PA.

Atlanta Boston Chicago Houston Kansas City Los Angeles New York Pittsburgh San Francisco Seattle Tulsa

Seriously—when you read Pittsburgh-Empire meters, you reap the greater revenue that results from in-built accuracy.

Next month brings high adventure with the girls afield—



Conduit coated and lined with Reilly Enamel is dependably protected and insured against corrosion from all causes. The tough, durable Reilly coating completely seals and insulates the outer surface against its environment, preventing corrosive agencies from coming in contact with the metal. As an inner lining, Reilly Enamel not only affords protection against corrosion, but also prevents tuberculation and incrustation, thus insuring full capacity flow for the life of the pipe.

This booklet, describing Reilly Coatings for all types of surfaces, will be sent on request.

REILLY TAR & CHEMICAL CORPORATION
Merchants Bank Bldg., Indianapolis 4, Ind.
500 Fifth Ave., New York 18—2513 S. Damen Ave., Chicago 8

Reilly Protective Coatings

LEADITE

Trade Mark Registered U.S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY

Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking